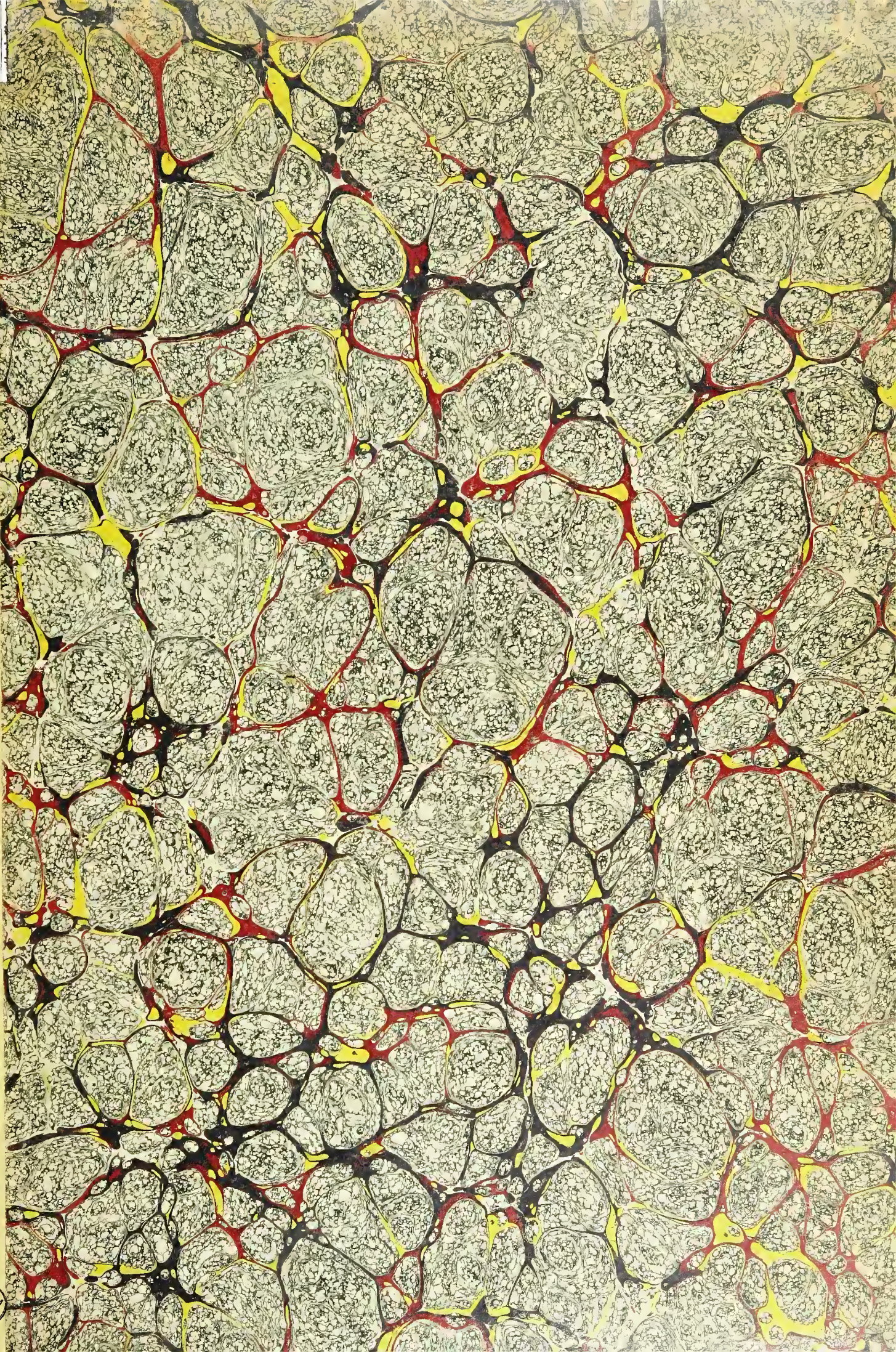


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HIGH-EXPLOSIVE SHELLS

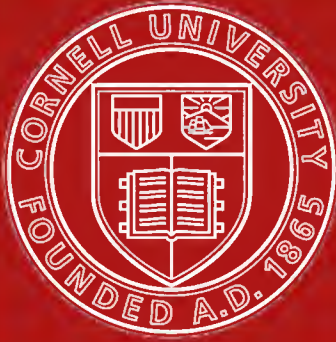
A REPRINT OF IMPORTANT
ARTICLES PRESENTED IN THE

American Machinist

From June to October, 1915



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High-Explosive Shells



FROM the beginning of the present European war careful observers have realized that it was a struggle between the technologic and industrial forces of the combatants—a struggle between manufacturing capacities and transportation services, just as much as a conflict between armies in the field and battle-ships on the sea. The truth of this realization is being more widely appreciated as the months pass by, and the importance of the machine shop in modern warfare is now generally recognized. In fact, the events of June, July, August and September, 1915, have impressed upon everyone that guns and ammunition are as necessary, if not more necessary, than men. Without machine-shop products fighting cannot go on today. But shop executives must know how to make munitions before they can turn them out in quantity. Thus the present need of information on the manufacture of ammunition and guns is most urgent.

The Ordnance Bureau of the United States War Department has begun to collect information from machine shops in the United States as to their capacity for manufacturing certain classes of ammunition, including explosive shells. This is preliminary work in preparing for any national emergency that may arise.

The request for these data puts a responsibility upon American machine-shop managers to acquaint themselves with the production problems, in connection with the manufacture of war material, and their solution. It is a patriotic duty to supply the information asked for by the Government, and the more knowledge American machine-shop executives have of the manufacturing operations and processes involved, the fuller and more accurate will be the data that they give.

In addition to this specific need for information on the manufacture of high-explosive shells, is the every-where present necessity of keeping in touch with the progress and changes in machine-shop practice. Today this practice is in a state of rapid development. The demand for production has shown the possibilities and capabilities of machines as they were never known before. Great ingenuity and skill are being used in devising jigs, fixtures and tools to perform operations on machines that would ordinarily be considered unsuitable for the work to be done. A record of all this is of value to everyone who must keep abreast of the progress of machinery building and the advancement of machine-shop practice.

To assist in satisfying these urgent needs, detailed information on the manufacture of high-explosive shells has been knit together in this reprint of important articles from the pages of the *American Machinist*. It supplements a previous pamphlet on "Shrapnel and Other War Material," which did for the shrapnel shell what this does for the high-explosive shell.

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What a High-Explosive Shell Is and Does

BY 2ND LIEUT. PERCY E. BARBOUR*

SYNOPSIS—In the early days of the war the contracts placed in the United States and Canada for ordnance ammunition were largely for shrapnel. After the struggle in Flanders and Eastern France settled down to trench warfare, orders began to be offered for high-explosive shells. This article shows what these shells are and gives a formula for computing the volume of any ogival projectile.

The modern high-explosive shell is an elongated hollow projectile which is filled with some type of high explosive, called a bursting charge, which is fired by a fuse provided in the nose of the projectile. Various types of American high-explosive shells are shown in Fig. 1.

Originally projectiles were round and were called bomb shells and were fired from the old smooth-bore cannon.

plosion forces the band to conform to the lands and grooves of the rifling in the bore of the cannon. This not only assures proper rotation, but the soft band is thus made to fill the entire cross-section of the bore and therefore to act as a gas check to prevent the powder gases from escaping around and in front of the projectile.

These copper rotating bands are forced into an undercut groove, cut around the projectile near the base. The band of copper is hammered in and the ends of the band beveled and scarf jointed or in the smaller calibers the band is cut from copper tubing and is forced into the groove by hydraulic pressure. Longitudinal or irregular cross grooves are made in the seat for the rotating band to prevent its rotation separately from the projectile. The outer surface of the rotating band is smooth for small calibers and is grooved for the larger calibers, to diminish the resistance of forcing the rotating band into the grooves



FIG. 1. GROUP OF AMERICAN TYPES OF HIGH-EXPLOSIVE SHELLS

Beginning at either end there is first an 8-in. armor piercing shell, weighing 323 lb. and requiring a propelling charge of 83.5 lb. of smokeless powder. Next comes a 10-in. armor-piercing shell weighing 617 lb. and requiring 182 lb. of powder. The short 12-in. shell is a deck-piercing projectile which weighs 824 lb. and requires only 20 to 50 lb. of powder. The next is a 12-in. armor-piercing projectile weighing 1070 lb. and requiring 334 lb. of powder. The one at the left has a soft nose, while that at the right shows only a small ring near the point by which this nose was originally held. The long 12-in. projectile is known as a torpedo shell. It weighs 1000 lb. and requires only 20 to 50 lb. of powder. In the center are two 16-in. shells, one being shown with and the other without the nose.

To increase the volume of the shell, it became necessary to change its shape and make it cylindrical, but an elongated projectile cannot be fired with accuracy from a smooth-bore cannon. It must have a rotating motion, which is given to it by the rifling in the gun, otherwise it will tumble end over end in the air.

MATERIALS OF CONSTRUCTION AND SHAPE

In order to get this rotating motion, the projectile is provided with a soft copper band near its base. This band has a diameter of from $\frac{1}{10}$ to $\frac{2}{10}$ of an inch greater than the caliber of the projectile and the force of the ex-

of the rifling, as well as to provide space for the metal forced aside by the lands.

With the adoption of high explosives for bursting charges in shells, greater strength in the walls of the shell became desirable, in order to insure against accidental explosion of the projectile while in the gun. For this reason cast iron, which was the common shell material heretofore, was succeeded by cast or wrought steel.

All shells have the same general shape, consisting of a cylindrical body with a pointed or ogival head, which shape for the head has been found by experience to be most advantageous in decreasing the wind resistance of the projectile in its flight and in increasing its penetration when

*4th Co., C. A. C., N. G. S. M.

it is fired against armor. The length of the projectile varies from $2\frac{1}{2}$ to 5 times the caliber of the gun.

The projectile does not have the same diameter as the caliber of the gun. The bourrelet, see Fig. 2, which is just behind the ogival head, has a diameter of about 0.01 in. less than the bore of the gun. The rotating band, as has been described, has a diameter greater than the bore of the gun until the force of explosion reduces it to take the lands and grooves.

Between the bourrelet and the rotating band the diameter of the projectile is about 0.07 in. less in diameter than the bore of the gun. This is to facilitate and cheapen the cost of manufacture, and to prevent any greater bearing of the projectile in the bore than is absolutely necessary for accuracy of fire.

FUSE AND CHARGE

For field work the shells are manufactured to take a nose fuse, which may be a time fuse or a percussion fuse or a combination of the two. In the first instance the fuse will explode after the lapse of the desired number of seconds. A percussion fuse is one which will explode only when the projectile meets with sufficient resistance, which of course is the case when fired at material objects. The combination fuse is a combination of the

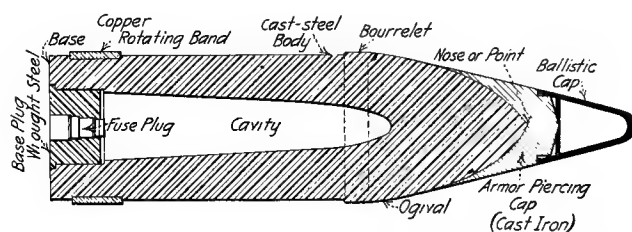


FIG. 2. SECTION OF ARMOR-PIERCING SHELL

two methods and insures the explosion of the shell when it falls, even should the time device fail.

The high-explosive shell carries from about 3% to 30% of its weight in high explosive, the amount depending upon the use for which the shell is destined. A smaller percentage is used when the shell is to be fired at men than when the purpose is to demolish a structure or destroy opposing artillery. However, the concussion of explosion of a heavily charged shell is as deadly as a flying fragment within a wide limit and the present European war is showing a very much increased use of the explosive shell against troops where formerly it was only used against artillery or fortifications. Its most important use is still against enemy trenches, barbed-wire entanglements, and artillery positions where it is simply a vehicle to carry to the desired spot as large a charge of high explosive as possible and detonate it there, to blow up the specified obstacle.

The most common size for use with infantry is the 3-in. shell. There is a logical reason for fixing upon this size. Experience has shown that, under average conditions, a horse cannot pull more than 650 lb. and be as mobile as the rapidly moving troop column. Six horses are provided for a 3-in. battery and the limit of weight within the required degree of mobility is therefore 3,900 lb. This is just about the weight of the 3-in. field gun, together with the carriage, limber, equipment and a reasonable amount of ammunition.

The largest gun in the United States mobile artillery is

the 6-in. siege howitzer, which fires a 120-lb. projectile. Some of the high-explosive shells fired against the armored forts in Belgium are presumed to have carried as much as 400 or 500 lb. of high explosives. The great destruction wrought by such large quantities of high explosives was evidenced by the wreck of those most modern and up-to-date fortresses along the Belgian frontier.

Artillery of position, consisting of guns permanently mounted in fortifications, use high-explosive shells of very much greater caliber and much different character. Inasmuch as this class comprises all of our seacoast defenses, the projectiles are designed for use against armor plate, and range up to 16 in. in diameter.

In seacoast projectiles the detonating fuse is invariably placed in the base of the projectile instead of in the nose, as in the case of mobile artillery. Time fuses are never used with this type of projectile. There are three types of seacoast projectiles, viz.: Armor-piercing shot, armor-piercing shell and deck-piercing shell. The first is intended to perforate the armor and to be exploded in the interior of the ship by a comparatively small bursting charge. The armor-piercing shell is not expected to effect complete perforation of the armor, but is expected to make some penetration and continue destruction by exploding against the partially ruptured plate. The deck-piercing

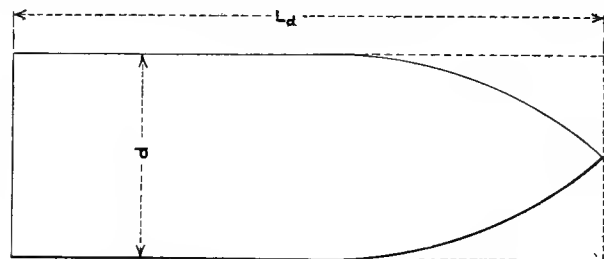


FIG. 3. OUTLINE OF OGIVAL PROJECTILE

shell is fired from high-angle-fire guns, has a nearly vertical fall and is intended to pierce the lightly protected decks of vessels.

Unlike the high-explosive shells of mobile artillery, the coast-artillery shells do not have the same sharp point or nose. They are equipped with a cast-iron cap, see Fig. 2, which increases the penetration of the projectile when it strikes the armor. The function of this cap is to prevent the deformation of the point of the projectile at the instant of contact with the armor plate. The advantage of this cast-iron cap is so great that an 8-in. capped projectile fired at a 3.5-in. plate effected complete perforation at a specified range, while a similar projectile uncapped, fired from the same range, indented the plate only $\frac{1}{2}$ to $1\frac{1}{8}$ in.

The wind resistance due to this blunt cap is very great and the new shells are being equipped with a ballistic cap or wind shield which is attached in front of the cast-iron cap and continues the taper of the ogival head and makes a long-pointed projectile. This so reduces the loss of energy due to wind resistance that in some cases the penetration is doubled.

VOLUME OF OGIVAL PROJECTILES

To compute the volume of ogival projectiles¹: Assume a solid cylinder, see Fig. 3, of the length and diameter of a given solid shot.

¹"Ordnance and Gunnery," Lt.-Col. O. F. Lissak, Ordnance Department, U. S. A., retired.

Let d represent the diameter of shot, usually taken as equal to the caliber of the gun.

L , the length of the shot in calibers.

The volume of the cylinder is $\left(\frac{\pi d^2}{4}\right) L d$.

Let B represent, in calibers, the length of the cylinder whose diameter is d and whose volume $\left(\frac{\pi d^2}{4}\right) B d$ is equal

to that part of the cylinder in the figure that is outside the shot. Subtracting this volume from the volume of the whole cylinder and representing by V_s the volume of the solid shot, we have

$$V_s = \frac{\pi d^2}{4} (L - B) d = \frac{\pi d^3}{4} (L - B).$$

$(L - B)d$ or $L - B$ calibers is the length of a solid cylinder whose diameter is the diameter of the shot and whose volume is equal to the volume of the shot. $L - B$ is called the *reduced length* of the projectile, in calibers, as it is the length of a cylinder of equal diameter and volume.

The length of B is a function of the radius of the ogive expressed in calibers. Its value, obtained by means of calculus, is given by the equation

$$B = Zn^2 (2n - 1) \sin^{-1} \sqrt{\frac{4n - 1}{2n}} - \frac{6n^2 - 2n - 1}{3} \sqrt{\frac{4n - 1}{2n}}$$

in which n is the radius of the ogive in calibers. When $n = 2$, the usual radius of the head in seacoast projectiles, $B = 0.58919$.

For cored shots, the reduced length is less than for solid shots by the length of the cylinder whose volume is that of the interior cavity. Representing by B' the length of this cylinder in calibers, the solid volume of the cored shot, or volume of the metal, is given by the equation

$$V_c = \frac{\pi d^3}{4} (L - (B + B')).$$

While the explosive shell for use against armament or artillery has an undisputed field, against troops of men it has been less commonly used than shrapnel but the present European conflict is likely to change the accepted theory of their relative merit. For use against a charging column or anything approaching mass formation or close order the high-explosive shell will probably do more execution than shrapnel.

Explosives Used with High-Explosive Shells

BY 2ND LIEUT. PERCY E. BARBOUR*

SYNOPSIS—The art of warfare has carried the development of explosives forward to a point undreamed of at the time of our Civil War. Cotton, coal-tar products, and nitric acid are the basic materials of three classes of modern explosives. From the cotton is made smokeless powder; from benzol is made tri-nitro-toluol or T. N. T.; from benzene, carboic acid is made, from this is made picric acid and the English lyddite, French melenite and other high explosives.

Cotton is the basis of the most important propulsive explosive used in modern warfare, viz., smokeless powder, which is also called nitro-cellulose, the principal ingredients of which consist of cotton or cellulose, nitric acid, sulphuric acid, ether and alcohol. The manufacture of this explosive is complicated only from a mechanical standpoint. There are no chemical mysteries about it.

Smokeless powder in the chamber of a gun is not intended to be detonated, but to be exploded by a progressive combustion, the result of which is determined by the characteristics of the gun or the service expected of it. The rate of the combustion depends upon the amount of surface exposed, hence the perforations in the powder grain which give this added surface.

CELLULOSE THE BASIS OF SMOKELESS POWDER

Nitro-cellulose is a general term applied to products resulting from the action of nitric acid on cellulose, in which the organic cellular structure of the original cotton

fiber has not been destroyed. Guncotton is a nitro-cellulose of high nitration, consisting of a mixture of insoluble nitro-cellulose with a small quantity of soluble nitro-cellulose, and a very small quantity of unnitrated cellulose. The chemical name for guncotton is tri-nitro-cellulose, and the formula is $C_{12} H_{14} O_4 (NO_3)_6$.

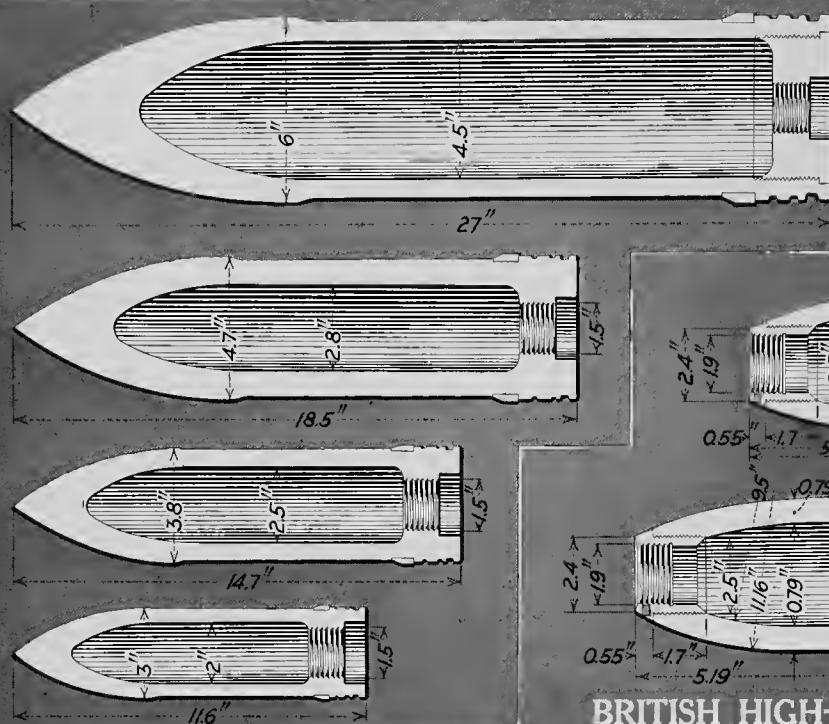
In the manufacture of nitro-cellulose, by varying the strength and the proportions of the nitric and sulphuric acids, their temperature and the length of time that the cotton is in them, a number of different products are obtained varying in the rate at which they will burn and the effects produced, and in the degree to which they are soluble in various solvents. This gives many different grades of explosives to which various names are applied at the will of the manufacturer and which are capable of a wide latitude of adaptability to different requirements.

Cordite is a British smokeless powder consisting of 37 parts of guncotton, 58 parts nitroglycerin and 5 parts vaseline. This powder gives a very high muzzle velocity with a low pressure in the powder chamber, but the temperature of its explosion is so high that it causes a rapid erosion of the bore of the gun. Therefore, another form of this powder, known as Cordite M. B., in which the ratio of the guncotton and nitroglycerin are reversed, has been made, which overcomes these disadvantages. This illustrates the possibilities of different combinations of the same materials to effect different purposes.

BENZOL, TOLUOL AND TROTOL

Increased interest attaches to benzol and toluol at the present time on account of the number of plants being constructed to manufacture them. They are used in the manufacture both of dyestuffs and high explosives for

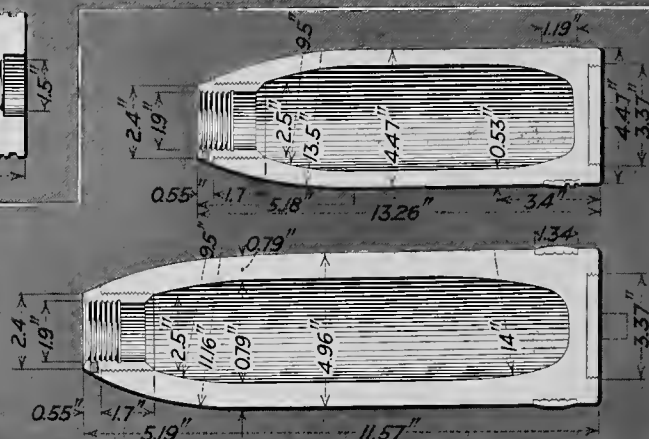
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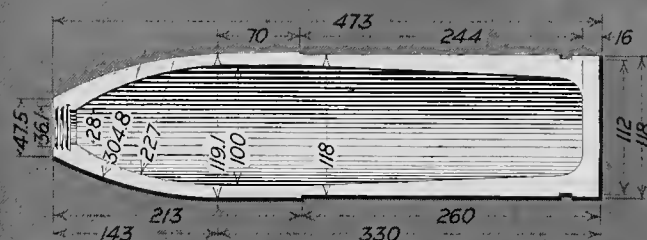
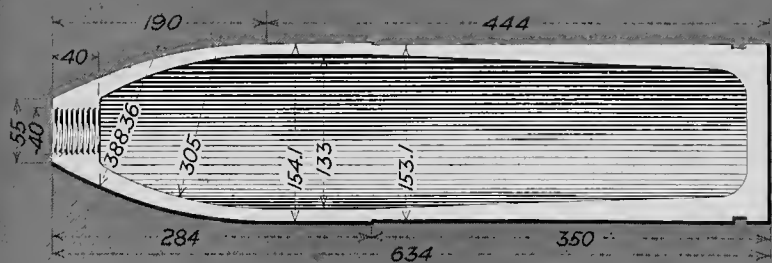
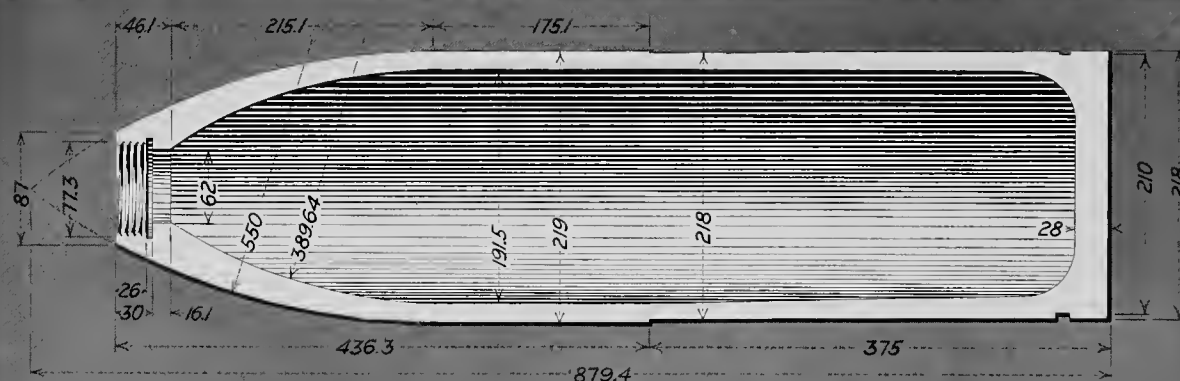
DIMENSIONS OF FRENCH SHELLS IN MILLIMETERS

DIMENSIONS OF OTHER SHELLS IN INCHES

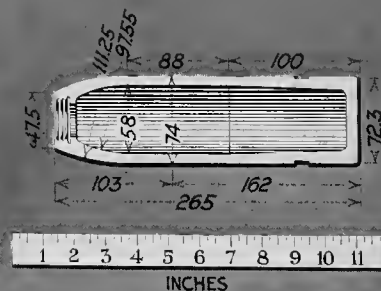
AMERICAN HIGH-EXPLOSIVE SHELLS



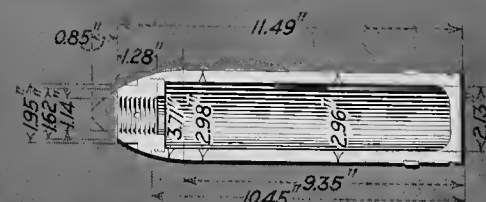
BRITISH HIGH-EXPLOSIVE SHELLS



FRENCH HIGH-EXPLOSIVE SHELLS



INCHES



RUSSIAN HIGH-EXPLOSIVE SHELL

war munitions. The United States Steel Corporation has three plants nearing completion—one at Farrell, Penn., one at Gary, Ind., and one at Birmingham, Ala. The Lehigh Coke Co. is building a benzol plant at South Bethlehem, Penn.; the Woodward Iron Co., Woodward, Ala., has a new benzol plant in operation; the Lackawanna Steel Co. has a benzol plant at Buffalo, and the Benzol Products Co., working with the General Chemical Co., the American Coal Products Co. and the Semet-Solvay Co., is building a plant at Marcus Hook, Penn., which will soon be in operation. The Dominion Steel Co. of Canada is manufacturing benzol on a large scale, and the Crows Nest Pass Coal Co. is also contemplating the building of a similar plant.

Benzol is a coal-tar distillation product comprising a mixture of benzene with variable quantities of toluene and other homologues of the same series. The Rittman process, of which we have heard so much lately, is a process whereby these products may be obtained from the distillation of petroleum, but at the present time they are only obtained commercially by distillation of coal-tar products, principally as a byproduct from coke ovens. The product known as "crude benzol" is further fractionally distilled, and by this means separated into pure benzene, toluene and other true chemical compounds. Benzene¹ is C_6H_6 and toluene is C_7H_8 . A 90 per cent. benzol is a product of which 90 per cent. by volume distills before the temperature rises about 100 deg. C. The composition of a 90 per cent. benzol is about 70 benzene, 24 toluene, and 4 to 6 of lighter hydrocarbons. Toluol is an impure form of toluene, so alike that the difference is only detected by a slight discoloration on the addition of sulphuric acid.

Toluene possesses the property of rendering oxygen very active and when treated with nitric and sulphuric acid and heated for several days, yields tri-nitro-toluene, an explosive of a high order which is superseding the use of picric acid as a base for shell fillers for artillery use.

Tri-nitro-toluene and tri-nitro-toluol are practically the same, and have been abbreviated to trotol or T. N. T. in United States Army parlance. This explosive, trotol, is also used especially for submarine mines and in the German 42-cm. guns and is next to picric acid, the most terrific explosive in the service.

PICRIC-ACID SHELL FILLERS

Benzene, a redistillation product from benzol, is used in the manufacture of carbolic acid or phenol; this in turn is the basis of picric acid, which latter is the base of most of the high explosives used at the present time in the European conflict. When phenol (carbolic acid) is treated with nitric acid, a nitrate called tri-nitro-phenol is formed. Its only use is as an explosive. It is not only an explosive of itself but more particularly is used as an ingredient of special explosive mixtures. Most of the new so-called shell-filler explosives are either picric acid or mixtures of picric acid salts called picrates. Among these are ecrasite (Austrian), lyddite (English), melinite (French), shimose (Japanese), etc. The exact compositions of these are secrets carefully guarded by the different governments.

The explosive used in the United States Army as a shell filler is known in the service as "Explosive D." This

is a picric-acid derivative, the exact composition of which is maintained a secret by the Government. Its relative force of explosion is twice as great as that of guncotton, which, of course, is ample recommendation for its use in any type of shell.

Picric acid, although a powerful explosive, forms in connection with lead, iron and some other metals very sensitive and dangerous compounds. This is true to such an extent that it is dangerous to paint the interior of a shell—which is to be loaded with a picric-acid derivative—with a paint which has either red or white lead in it, and it is also dangerous to use red or white lead in screwing in a base plug. Trotol does not have this disadvantage, and it is for this reason that it is displacing, in this country at least, picric-acid explosives.

Both picric acid and trotol are safe to handle and are loaded into the shells either by hand, in which case they are tamped in solidly with wooden rammers and mallets, or they are compressed into the shell cavity by machinery.

Owing to their relative insensitiveness, a very strong detonator is required in the shell to cause their explosion which, unlike the slower explosion due to the inflammation of propulsive powders, is desired to be as instantaneous as possible to produce the greatest shattering and destructive effect.

✱

Steel for High-Explosive Shells

The steel for high-explosive shells can be produced either by the "acid-openhearth" or the "stock-converter" process. When produced by the stock-converter process, nonphosphoric pig iron must be used. The steel must be of the best quality, homogeneous, free from flaws, seams and piping. Apart from the iron the following chemical elements may occur in the percentages given in the table herewith:

	Minimum Per Cent	Maximum Per Cent.
Carbon		0.55
Nickel		0.50
Silicon		0.30
Manganese	0.40	1.00
Sulphur		0.40
Phosphorus		0.40
Copper		0.10

To insure sound material free from piping, 40 per cent. is cut off from the top of each ingot.

The parting of the forging blanks is done after the ingot is cold, by sawing or turning and breaking. The area of the fracture should be one-sixth the sectional area of the ingot if only one shell is to be made from it, and one-twelfth, if more than one.

The base end of each blank is to be marked, and this end will be the base end of the forging. Each blank shall carry the steel maker's cast number and ingot number throughout manufacture. No hardening, toughening or similar treatment is permitted.

The steel must have a yield-point of 43,000 lb., ultimate strength between 78,000 and 110,000 lb., elongation in 2 in., 20 per cent. A cylinder of the metal of a length equal to its diameter must stand compressing cold to one-half its original length without cracking.

Material for brass parts of shells should contain 60 parts copper and 40 parts zinc. The brass parts are preferably press-forgings formed under a unit pressure of 75 tons per square inch. The metal must have a yield-point of at least 13,500 lb., and ultimate strength of at least 27,000 lb., with elongation of 10 per cent. in 2 in.

¹Benzene is a distillation product from petroleum.

Casting Steel Forging Blanks for 4.5-In. Explosive Shells--I

By E. A. SUVERKROP

SYNOPSIS—In the foundry, at Longue Pointe, Montreal, Canada, controlled by the Canadian Steel Foundries, Ltd., ingots for four thousand 4.5-in. howitzer shells are cast every 24 hr. in permanent molds of cast iron with a life of over 200 heats. Each ingot, besides the "crop," has sufficient metal for two shell blanks. The "crop" and blanks are parted in axle lathes specially arranged for the purpose.

The art of casting steel in permanent molds dates back to the earliest days of crucible-steel manufacture, when

As a matter of fact there is no chilling effect—that is to say, no hardening due to casting in metal molds, although there is a chilling effect in the sense that there is a shortening of the cooling time. No annealing is necessary however, the ingots, as soon as possible after casting, being knocked out of the molds and sent to the machine shop.

The government requirements for this steel are the same as those for the bar steel used for the production of the forgings for the 15- and 18-lb. shrapnel. It must have a yield point of at least 19 long tons; tensile strength between 35 and 49 long tons and elongation of 20 per cent. The carbon must be between 0.45 and 0.55 per

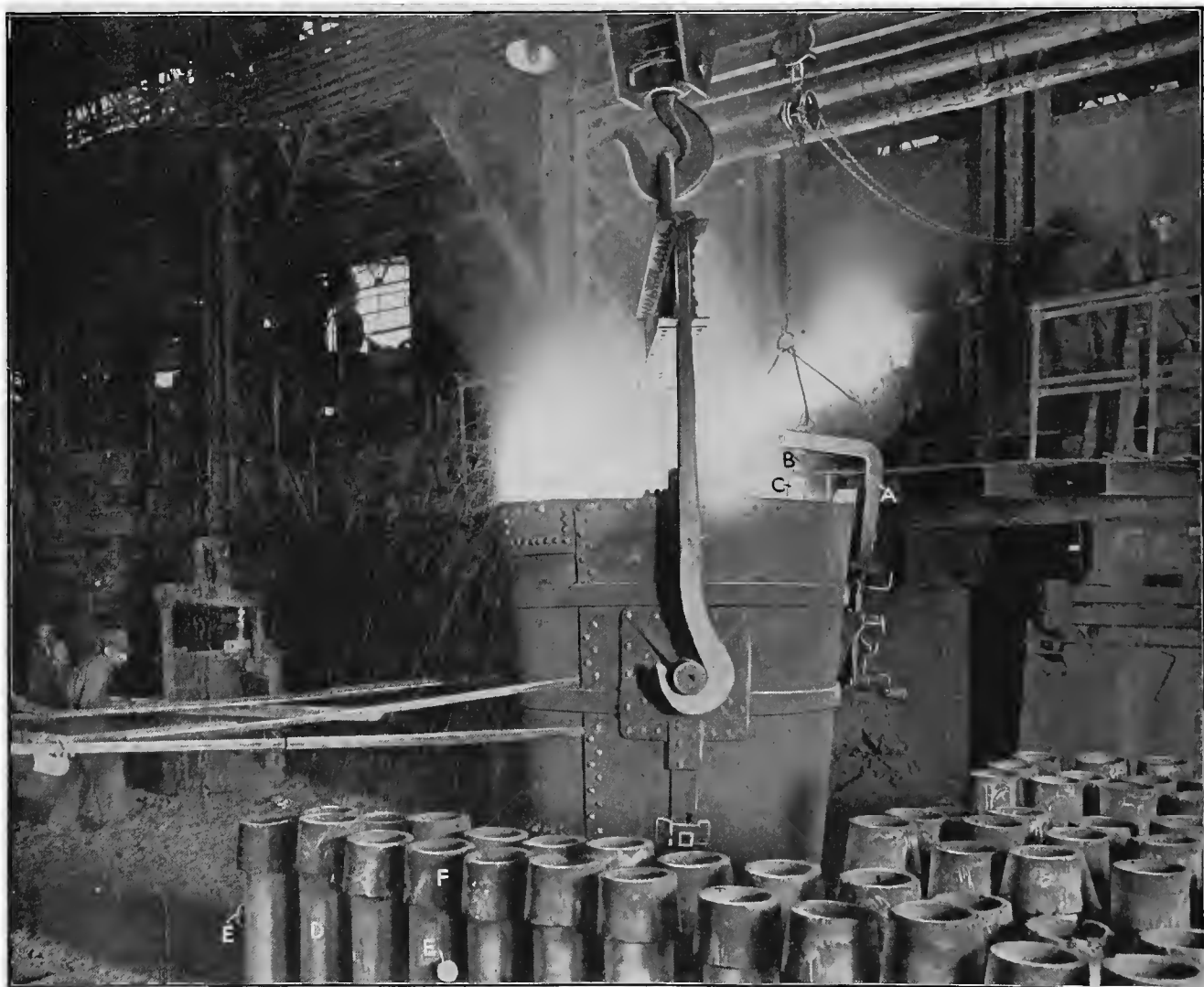


FIG. 1. CHARGING THE 40-TON LADLE

tool-steel ingots 2 in. square were cast in metal molds. Today, both low- and high-carbon steels are cast in metal molds.

The man familiar with iron-foundry practice would expect chilling of the steel to result with a consequent long annealing operation to render the metal machinable.

cent.; nickel under 0.50; manganese between 0.4 and 1.0; sulphur and phosphorus under 0.05.

THE MIXTURE

A steel fulfilling these demands is obtained from the following mixture:

About 20 per cent. Chautauqua or similar low-phosphorus pig iron, 40 per cent. openhearth scrap steel and the balance low-phosphorus heavy-melting scrap steel. At the present time scrap from the Quebec bridge is being used for the last item. The steel is produced in two 30-ton furnaces by the acid openhearth process. These are fired



FIG. 2. GROUP OF OLD-TYPE MOLDS AFTER POURING

with ordinary fuel oil at a pressure of 80 lb. per sq.in. and air at 100 lb. per sq.in.

The consumption of oil is very low, amounting to 33 or 34 gal. per ton of melt. The time necessary to melt a charge is about five hours.

THE LADLE

The entire charge of 25 tons of steel is run from the furnace into the 40-ton bottom-pouring ladle, shown in Fig. 1. For the benefit of those not familiar with this

threaded hole, so that it can be screwed on the lower end of the 2-in. rod *B*, Fig. 1. The rest of the rod is protected from the molten steel by a series of disk-shaped firebricks *C* which are strung on it. The graphite plugs will stand up for about 300 openings and closings before erosion makes them useless as stoppers.

THE MOLDS

In this plant, as in all other Canadian plants, when the call came for ammunition the management went right ahead with the job and lost as little time as possible. Molds were made ready in a hurry, and the job started. Some of the early molds appear at *D* in Fig. 1; many have had as many as 200 ingots cast in them, and are still in use. The early ingot molds are approximately 21 in. long with a straight $4\frac{1}{8}$ -in. hole in them and a wall $1\frac{1}{2}$ in. thick. The trunnions *E* on each side, a little above the center of their length, are intended to facilitate handling with the crane. The molds are faced on each end and are given a slight rub with fish oil preparatory to casting. They are stood on end on machined plates of cast iron and are held down by gravity only. A runner cup *F* is laid on top of each mold. These cups are made of facing sand in an ordinary core box, washed with silica wash and baked in the core oven.

In this, as in all work, experience has been a great teacher. The early molds produced ingots with large heads, which presented certain difficulties in the machine shop where the shell blanks are parted in the lathe. With them, centering of one end is necessary. While this does not require a great deal of time, the entire elimination of it, or any other unnecessary operation, is desirable, as the production of shell blanks consists of a large number

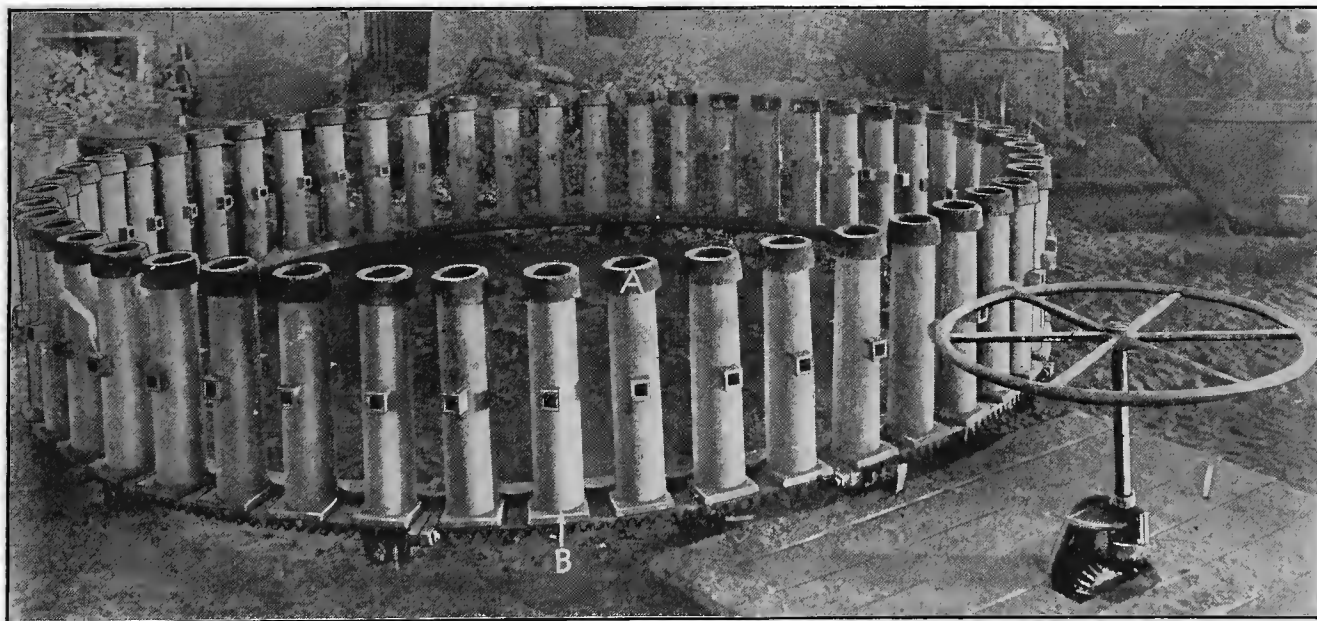


FIG. 3. THE ROTARY POURING TABLE

work, a description of the ladle may be of interest. It is made of heavy boiler plate lined with firebrick. At the bottom is an opening, which is closed by a plug or stopper operated by a lever in conjunction with the mechanism *A*, Fig. 1. The plug which stops the hole in the bottom of the ladle is made of graphite, conical in shape with the end entering the hole somewhat rounded. The other end of the plug is flat and in its center is a

of operations requiring a comparatively short time to perform.

The old method of grouping the ingot molds is shown in Fig. 2. This method required the moving of the traveling crane, with its 30- or 40-ton burden of ladle and metal, from mold to mold.

The movement of the crane must of necessity be quickly and accurately made to bring the spout over the pouring

cups, and the ladle must be prevented from swaying so that metal will not be wasted by spilling, all of which are somewhat difficult to control.

THE NEW MOLDS AND ROTARY TABLES

These difficulties led to the designing of new molds to produce ingots which would not need to be centered and to a new method of handling, having the ladle stationary and the molds so mounted on a circular table that by turning a handwheel they could be brought under the stationary ladle in rotation.

In Fig. 3 one of the rotary pouring tables is plainly shown. These tables consist of a series of cast-steel segments bolted together to form a circle. The lower face is provided with a circular rack. Rollers support and guide the table. The handwheel operates the turning mechanism, four men being required to operate the turning apparatus.

The molds here shown are the new type. They are 33 in. long with a $4\frac{1}{8}$ -in. hole in them. The wall is $\frac{1}{8}$ in. thick. The trunnions are rectangular, 3 in. square, with a 2-in. square opening in them; they project 2 in. from the side of the mold.

The runner cups *A* are smaller than those used on the old type of mold, so that when shrinkage is complete, they leave either a very small head, which is readily broken off, or no head at all. Where they rest on the mold, they are $9\frac{1}{2}$ in. diameter, tapering to $8\frac{1}{2}$ in. at the top. They are 4 in. deep, and the pouring hole is 6 in.

gear and the valve operator (not shown), who manipulates the opening and closing of the valve in the ladle through the lever *B*. The entire heat is run off in about 55 minutes.

The walls of the molds should be thick enough to prevent them getting too hot and cracking. A further objection to a thin wall is the liability of the molten steel heating the inner surface of the mold to a temperature where welding of the two would result. At this writing four heats are run every 24 hr., with a production of 300

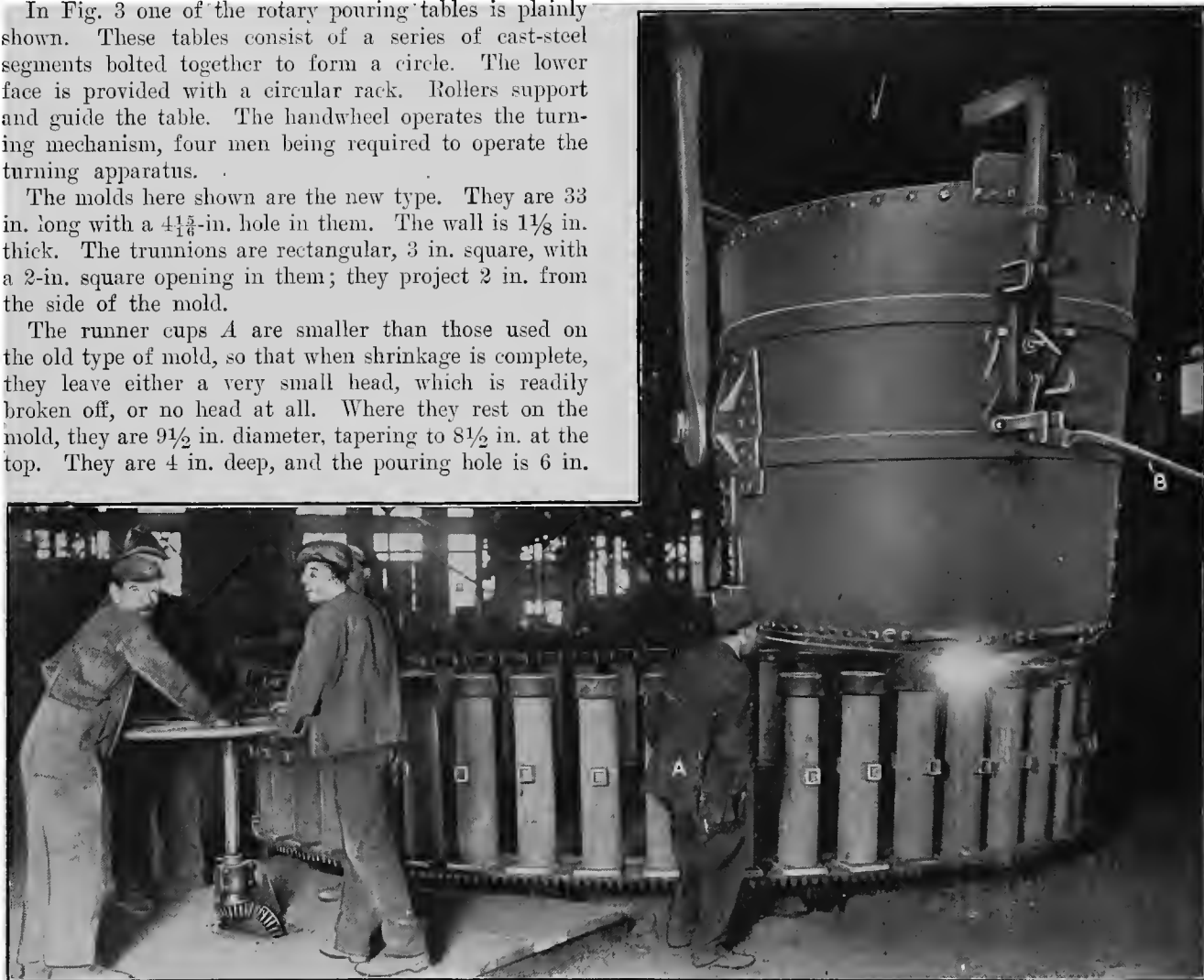


FIG. 4. POURING THE INGOTS

diameter at the top, tapering to 3 in. on the end next the mold.

The circular tables, of which there are four, are 16 ft. 8 in. inside diameter and 18 ft. 4 in. outside diameter. Fifty machined rectangular surfaces *B* provide accommodation for 50 molds. A new table is now being designed which will accommodate two concentric circles of molds, thus increasing the capacity 100 per cent. without any increase in floor space occupied.

POURING

The 40-ton ladle is picked up by the crane and suspended over one of the molds in the position shown in Fig. 4. The man at *A* is provided with heavy blue-glass goggles and directs both the men at the turning

ingots per heat, or approximately 2400 shell blanks per 24 hr. Both the old and the new methods of pouring are in use, as the demand for shells makes it imperative to get the work out by any and all means available. However, by the time this article is in print, seven heats of 25 tons each will be run every day, with an output of 4000 shell blanks every 24 hours.

LOSSES IN CASTING

Forty per cent. of each ingot (or 13 in. of the long ingots) is cropped off. This part contains the "pipe" due to shrinkage, which measures 2 to 3 in. diameter at the top and tapers to nothing, generally in considerably less than the 13 in. mentioned above. Another cause of loss is seizing in the mold. The shrinkage of this steel,

cast in ingots of this diameter, is about $\frac{3}{8}$ in., which is usually ample to free it and permit ready removal from the mold. However, a small percentage of the ingots seize at both ends of the mold before the metal is properly "set" in the center. Then, when further cooling and endwise shrinkage take place, the ingots occasionally pull apart in one or more places.

The loss by this and other defects is, however, very slight, amounting to about 3 per cent. only, which

occasionally the hammer fails to remove them. They are then pushed out with the aid of the large Bertram hydraulic press shown in Fig. 6.

FIRST INSPECTION

The ingots after removal from the molds are loaded a large number at a time in heavy tote boxes made of boiler plate or cast steel, and while still hot taken to the inspection floor, where they are carefully examined



FIG. 5. KNOCKING OUT THE INGOTS

will probably be lessened, as preventive measures are discovered.

EMPTYING THE MOLDS

When the ingots are properly set, but by no means cold, the molds are emptied ready for the next heat.

In Fig. 5 two of the gang are shown knocking out an ingot which has stuck in the mold. With few excep-

for cracks or other defects which would render them unusable. After inspection, those with the large heads, cast in the old-type mold, are centered on the head-end ready for the lathes. Those cast in the new-type molds have either no head at all or a small one, and as the large end of the shrinkage "pipe" passes through the base of the head, causing the wall to be thin, such heads are comparatively easy to break off, leaving the end smooth enough for the reception of a false center. This false center is merely a steel cap which is slipped over the end and secured with two setscrews 120 deg. apart. It is provided with a large countersink to receive the tail center.

❧

Just as the Civilian Heads of departments in munition manufacturing plants may ignore the experience of the army officer, so this officer in turn too often ignores the man in the shop who is to make the ammunition the officer has designed. And this very fact is holding up the production of war material more than we realize. One type of primer plug, for example, an innocent looking little piece of brass a little over an inch in diameter and about the same in length, is said to have 84 inspection gages used on it. A good shopman could probably reduce this to 8 and secure plugs that were equally satisfactory. These gages include the root and outside diameter of thread, but quite ignore the real essential—pitch diameter; in fact several of the inspection officers didn't know such a thing existed. A short thread of fairly coarse pitch must run out into a groove next to a shoulder. This groove is so narrow that it is impossible to run a full thread clear over it with a die, so a hand-sizing die must be run on afterward. And exactly the same result could be secured without any groove, by simply counter-boring the hole into which it screws in the base of the cartridge. The essential part of all this is that it retards production which in time of war is far more important than the added cost of manufacture.

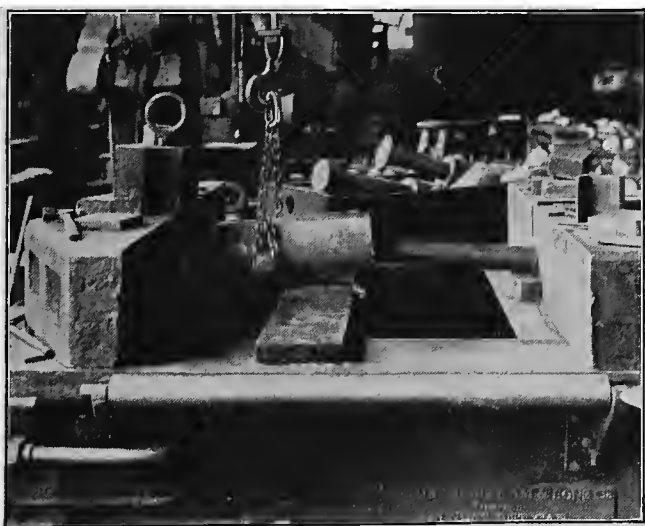


FIG. 6. PUSHING A STUCK INGOT OUT

tions, the ingots slide out of the molds as soon as they are lifted by the crane. The bulk of those that do stick usually respond to a single lick with the hammer, but

Casting Steel Forging Blanks for 4.5 Explosive Shells--II

By E. A. SUVERKROP

SYNOPSIS—In this continuation of the description of methods employed at the Canadian Steel Foundries, Ltd., the parting and breaking of the ingots are shown; inspection methods are detailed, and the chemical analysis of the metal is given, together with its physical properties.

The government specification for shell blanks produced in this way requires that one-sixth of the cross-sectional area shall be left for breaking, so that the fracture may be inspected.

At present five heavy lathes are running night and day on the cutting-off job. Two of these are Bridgeford and three Bertram axle lathes. One of the Bertram lathes is shown in Fig. 7. The arrangement of all the lathes is, however, practically the same. A simple chuck, with a hinged clamping member *A* and swing-bolt, have been mounted on each side of the central driving head.

There is an operator for each carriage. The parting tools are forged from Firth high-speed steel 1x2 in section, and vary from $\frac{3}{8}$ to $\frac{1}{2}$ in. wide in the cut. The speed of the work depends on the hardness of the stock, which varies slightly from heat to heat. The depth of cut is approximately 2 in. The feed is by hand and is all

The placing and removal of the ingots is a simple matter. The hinged chuck clamp is thrown back; the base of the ingot laid in the groove in the fixed portion of

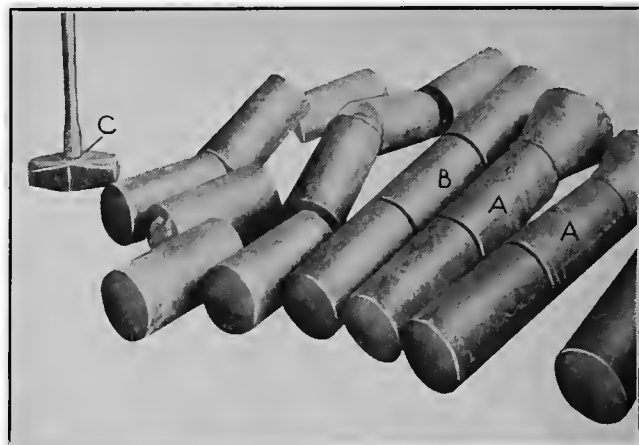


FIG. 8. BREAKING OUT THE BLANKS

the chuck; the other end lifted with the aid of a bar; the tailstock tightened; the chuck clamp closed, and the nut tightened. The long ratchet wrenches *B* (similar to the one lying on the left-hand carriage and leaning

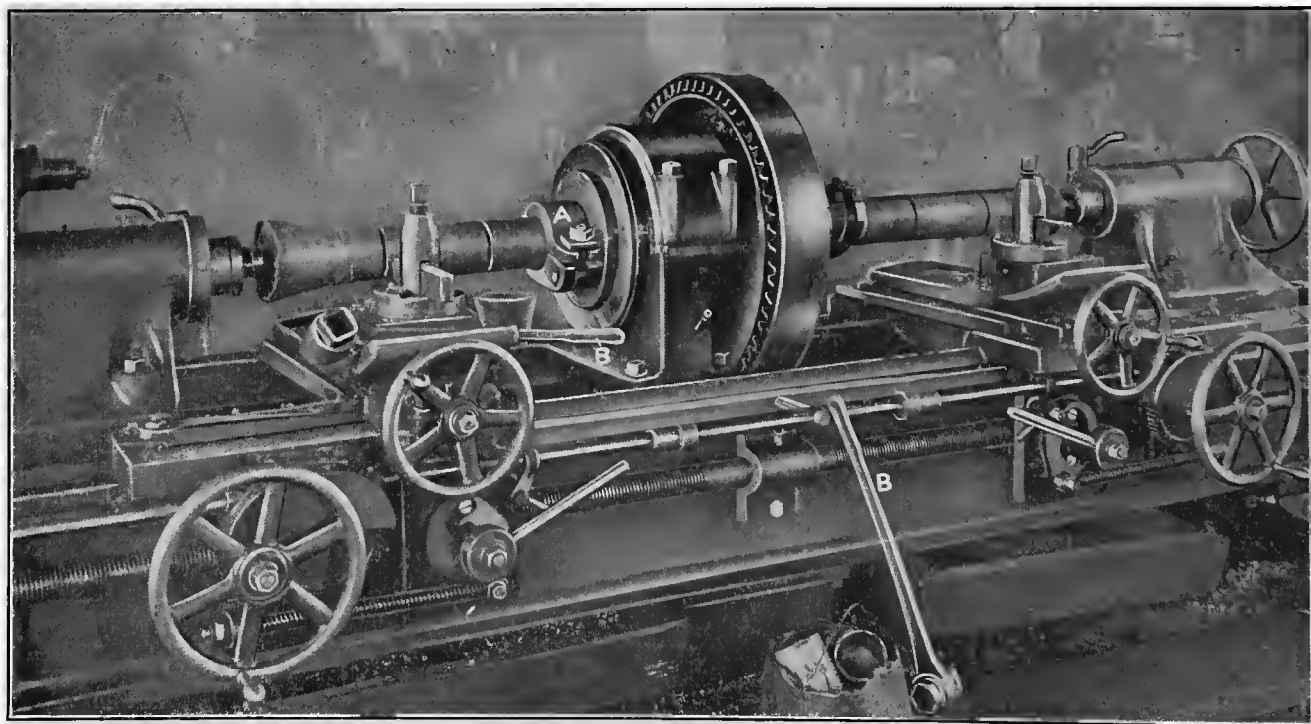


FIG. 7. PARTING THE SHELL BLANKS ON HEAVY AXLE LATHES

that the tool will stand. Each lathe hand has the use of a helper for placing and removing the ingots, which weigh approximately 156 lb. each. A handy jib crane with air hoist is now being made to take the place of the helpers on this job.

against the trip rod) are extensively used throughout the works. They are great time-savers.

Placing the work, taking the four cuts and removing the work from the lathe averages about 12 min., so that the output per lathe is about 200 shell blanks, $9\frac{1}{4}$

in. long, in 10 hr. The men handling the job are helpers who have been taught to do this one thing only. This arrangement of two men at a lathe having a single driving head is conducive to a high rate of output, for if the

seconds for each blank and would take *some* beating by any other method!

It will be noted that there is but one cut in each of the old type ingots *A*. While many of them produce

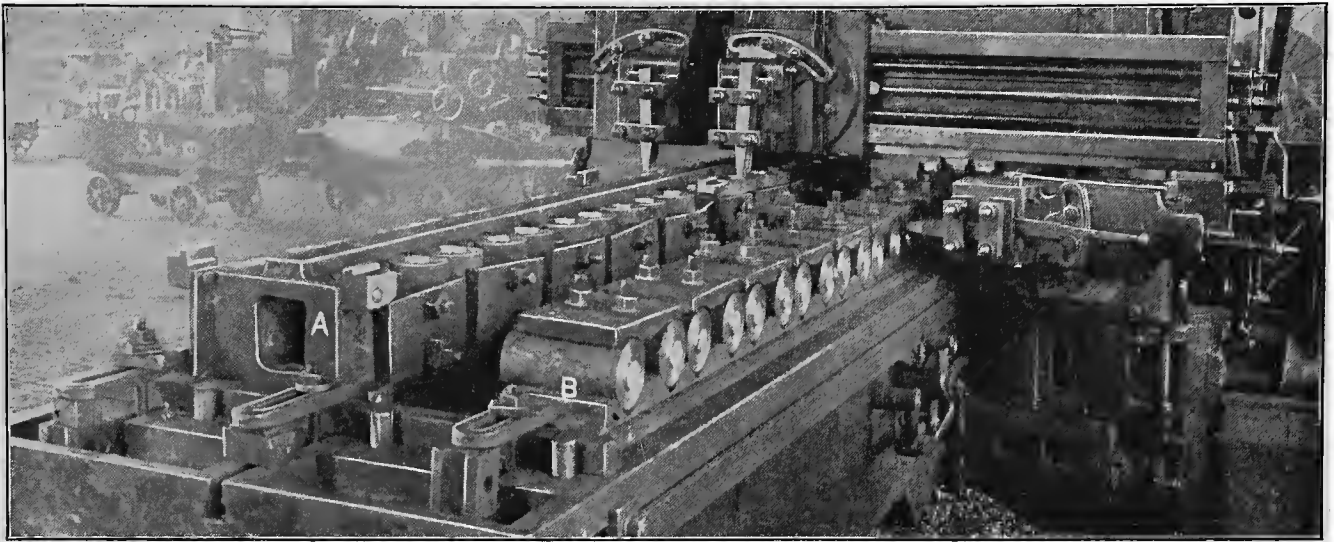


FIG. 9. PLANING THE BUTTONS OFF

one man takes longer to make the two cuts than the other, he is liable to have his mate on his neck in no time.

BREAKING OUT THE BLANKS

After being taken from the parting lathes, the ingots are laid on the floor with one end resting on a 3x4-in. piece of timber, as shown in Fig. 8. This illustration also shows very plainly the difference between the old-type

two shell blanks, a higher percentage of them, as compared with the new type, have imperfections which condemn the upper blank.

SECOND INSPECTION

After breaking, the blanks and crop ends are loaded into separate boiler-plate tote boxes. The crop ends are returned to the foundry for remelting, and the blanks

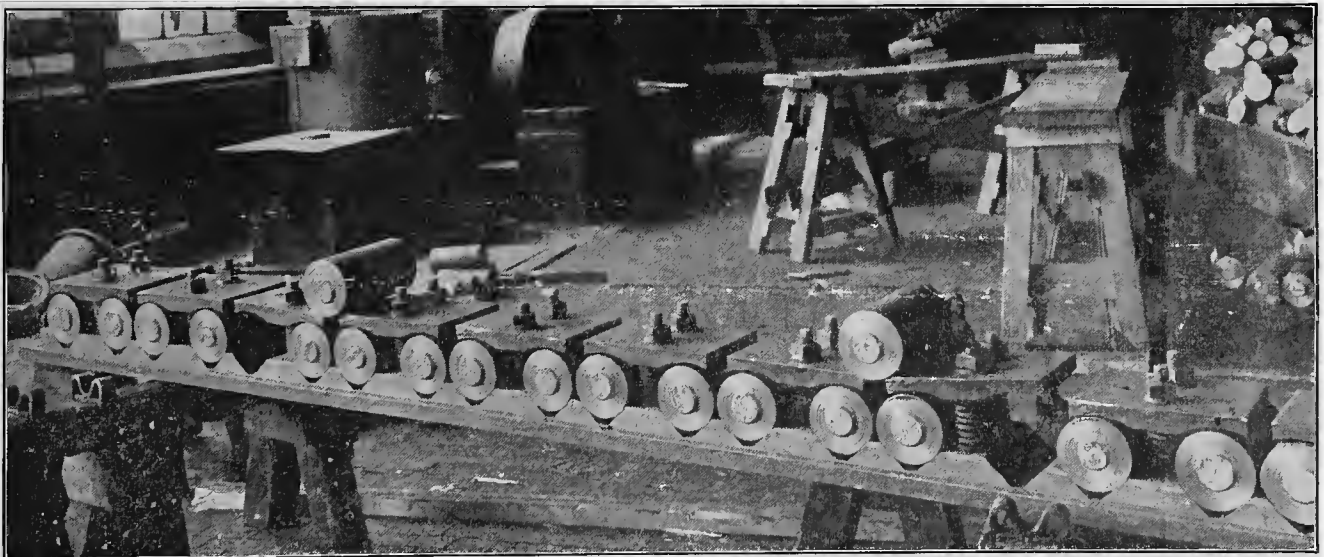


FIG. 10. LOADED JIG AND TWO GOVERNMENT INSPECTOR'S BENCHES

large-headed short ingot at *A* and the new-type long headless ingot at *B*. The first method tried for breaking was to put the ingots in a horizontal hydraulic press, but this is one of many jobs which are more quickly and satisfactorily done by hand. The hammer *C* has a handle about 3 ft. long. On two occasions, unknown to him, I timed the young fellow who swings this hammer—on the first he hit 23 licks in 45 sec. and broke out 20 shell blanks, and on the second he hit 11 licks in 20 sec. and broke out 10 shell blanks. This is pretty close to two

go to the government inspection tables. Each table is manned by two inspectors and two helpers. It is a piece of 2-in. pine, 12 in. wide and about 6 ft. long, supported on well-braced trestles.

A helper takes a blank from the tote box and lays it on the table. One of the inspectors rolls it along the table, examining it carefully for cracks. It is then inspected on the ends for possible "pipes" and defective fractures; having been inspected, the second inspector at the end of the table stamps it. His tools consist of a

3-lb. hand hammer and three steel stamping letters, 'B R W.'

When rejected, the blanks are stamped "R." Those that pass are marked at the base-end, that is, the end which later is placed downward in the forging operation,

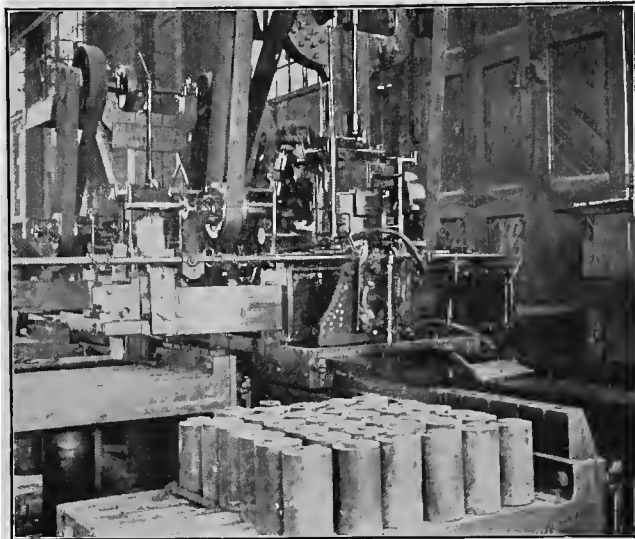


FIG. 11. MORTON DRAW-STROKE SHAPER

with the letter "B" and also the letter "W," which is the symbol signifying that the work is from the Longue Pointe Works of the Canadian Steel Foundries, Ltd. When the parted blanks come quick enough, two inspectors

In Fig. 9 is shown a Bertram open-side planer working on this job. The heads on the cross-rail serve the double jig A, which holds 40 shell blanks, while the side head takes care of the 20 blanks in the single jig B. Two sets of jigs are used, and while one set is on the planer, the other is being emptied and refilled with blanks. The output for 10 hr. on the planer is 450 shell blanks.

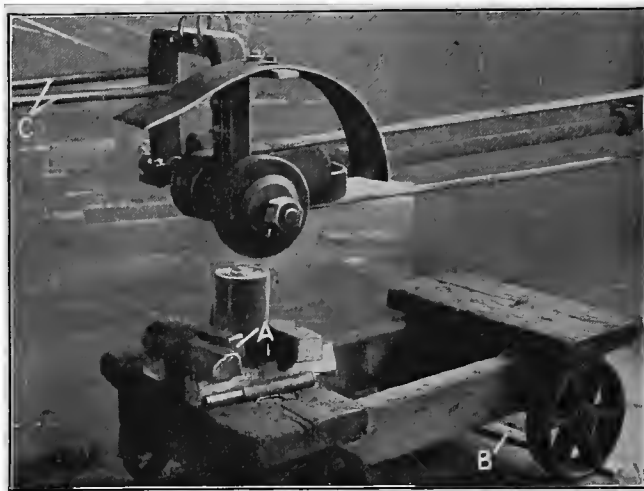


FIG. 12. GRINDING BUTTONS

After planing the buttons off one side, the jig A is turned over and the jig B is turned end for end to present the buttons on the other side to the tools.

In Fig. 10 in the foreground is shown a single jig

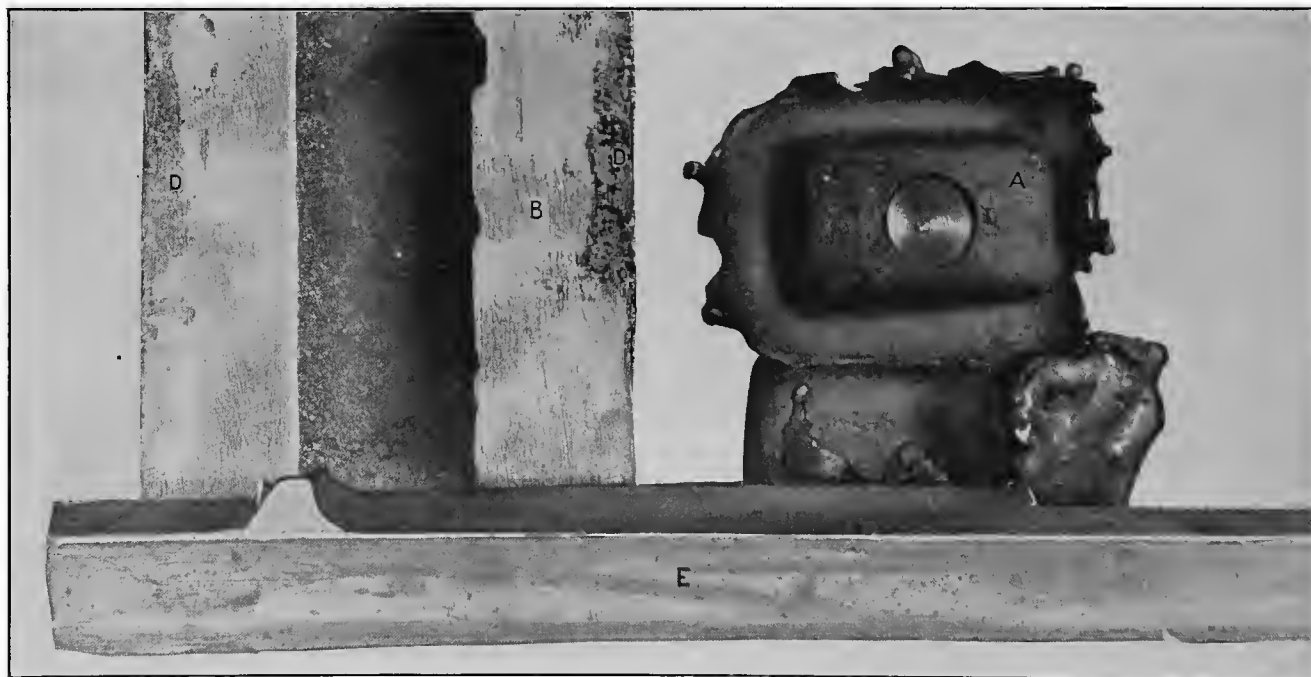


FIG. 13. TEST PIECE SPLIT CASTING AND FORGED TEST PIECE

and two helpers can pass them at the rate of about three to four per minute.

REMOVING THE BUTTONS

The round projection left at the point of fracture is removed by planing, shaping and, if there is not too much metal to remove, by grinding.

partly loaded, and in the background two of the government inspectors' benches. From the two illustrations the construction of the jig will be made clear.

In Fig. 11 is shown a large Morton draw-stroke shaper with two heads mounted on the long rail. The rail is provided with four knees. This tool is just being prepared for the button-planing job.

Where the buttons are not too thick, they are removed by grinding on the machines shown in Fig. 12. These tools were formerly used for grinding manganese-steel rails, etc., which form a large part of the foundry output.

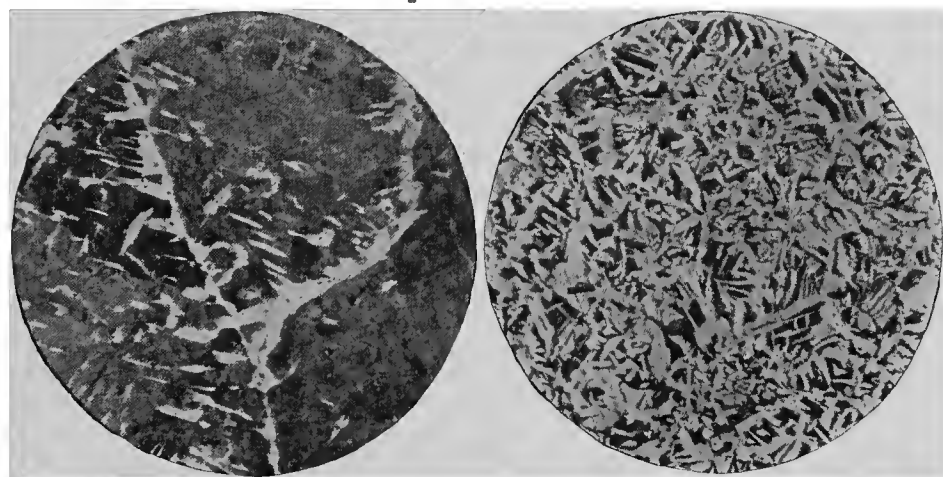


FIG. 14. 42-CARBON STEEL AS CAST FIG. 15. 42-CARBON FORGED SAMPLE

The shell blank is "chucked" with the wedge A, and the truck rolled in under the abrasive wheel until its wheels are stopped by the bar B. The direction of rotation of the wheel keeps the truck against the stop. The operator applies pressure to the wheel by leaning on the two bars C. By this method from 150 to 175 ends per man can be ground in 10 hours.

Two sample ingots for analysis are usually taken from each heat. One of these, shown at A, Fig. 13, is obtained when about one-third of the heat has been run off, and the other at the end of the run. In case of necessity, a complete analysis can be run through in an hour, but there is generally plenty of time to run the analysis before the ingots are ready to be cut into blanks.

Drillings are taken from the test-block and analyzed for carbon, sulphur, phosphorus and manganese. The carbon content is ascertained by the combustion method as the color method gives only an approximation, except when the standard has been given exactly the same treatment as the sample.

At B in Fig. 13 is shown the upper blank from an ingot, split in halves lengthwise; a slot was planed on opposite sides, and wedges were used to split it. The planed surface is clean and close-grained. The dark patches at D are bruises from the wedges. At E is shown

phorus. This steel in the ingot state has a yield point of 10 long tons and tensile strength of about 40 tons.

In Fig. 15 is shown a sample from the same heat as that in Fig. 13, but taken from one of the shell blanks after forging. Forging blank has brought the yield point up to 19.2 long tons. The tensile strength is 40.7 long tons, just about the same as in the un-forged casting. The elongation is 25.7 per cent.

Drillings for analysis are also taken from several blanks from each heat. A 3/4-in. drill is run in 1 1/2 in. in the cut end, as shown in Fig. 16, so there will be no scale to influence the analysis.

Chemical and physical tests are made of each heat, both by the works chemist and by the government. Records are kept

of each and every melt. The metal, as cast, must also withstand a compression test. The test piece is in the shape of a cylinder the height of which is equal to the diameter. This cylinder must stand compression to one-half the height without showing cracks.

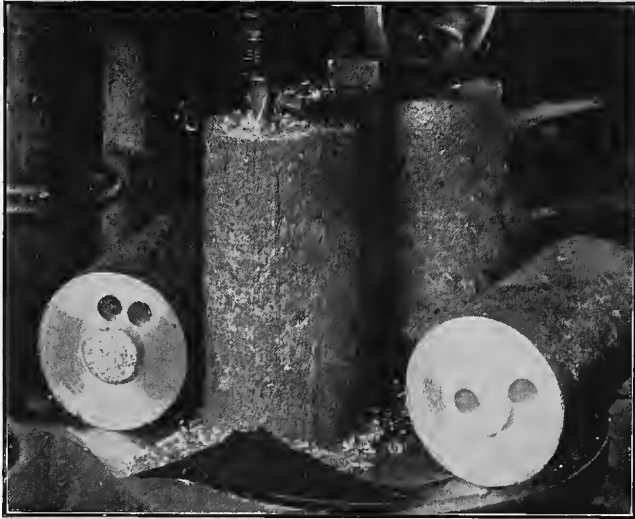


FIG. 16. OBTAINING DRILLINGS FOR ANALYSIS

HEAT NO.	DESCRIPTION	DIA.	AREA	ELASTIC LIMIT		MAX. STRENGTH		ELONGATION 2 1/2 IN.		REQ. DIMENSIONS			CHEMICAL ANALYSIS					
				ACTUAL	PER SQUARE INCH	ACTUAL	PER SQUARE INCH	IN.	PER CENT	DIA.	AREA	PER CENT	C	P	MN	S	SI	VA
	45 Hards	.461			19.2		40.70		25.7				.42	.031	.72	.032	.28	
	Shell	"			21.9		41.8		27.6				.41	.036	.85	.032	.30	
					22.3		42.0		26.3				.40	.036	.87	.034	.27	

TABLE OF CHEMICAL ANALYSES AND PHYSICAL TESTS OF COUPONS FROM FOUR HEATS

a test-bar in the rough, taken from a forged blank from the same melt.

In Fig. 14 is shown a reproduction from a photo-micrograph of the metal in an ingot containing 0.42 carbon, 0.28 silicon, 0.72 manganese, 0.032 sulphur, 0.031 phos-

phorus. In the table are shown analyses and physical properties of four heats, running from 0.38 to 0.42 per cent. carbon. The physical tests were made from test-bars cut from forged shell blanks and the analyses were found to prove out as described.

Forging the Blanks for 4.5-In. High-Explosive Shells

By E. A. SUVERKROP

SYNOPSIS—At the Dominion works of the Canadian Car & Foundry Co., Ltd., these forgings are made from solid blanks $4\frac{3}{4}$ in. diameter and 9 in. long, cast in ingot molds. In three operations—one under the steam hammer and two in hydraulic presses—they are hot-forged into cups approximately $4\frac{7}{8}$ in. diameter and $12\frac{3}{4}$ in. long outside, with a $3\frac{1}{8}$ -in. hole extending down to within about $1\frac{1}{2}$ in. from the bottom.

Many of the difficulties encountered both in forging and manufacturing the 4.5-in., or 35-lb., high-explosive shell are attributable to the comparatively small diameter and great length of the central hole. The greatest diameter of the shell when finished is 4.48 in., and of the shell forging in the rough, about $4\frac{7}{8}$ in., so that when the hole

In Fig. 1, from left to right, are shown the stages of manufacture. At A is the steel casting as delivered by the Canadian Steel Foundries, Ltd., to the Dominion Works of the Canadian Car & Foundry Co. The blank shown is $4\frac{1}{8}$ in. diameter and 9 in. high. The cast blanks weigh from 46 to 48 lb. each, the variation being due to slight differences in diameter. A difference of $\frac{1}{16}$ in. in diameter on a blank of this size causes a difference of about one pound in the weight. The center-punch marks on the top of A near the edge indicate the melt number and also that it is a test blank which is to be forged. It must pass both chemical and physical tests before the rest of the blanks bearing that melt number are shipped from the foundry. All blanks have the melt number stamped with ordinary steel stamps on their sides, but as this would be obliterated by the forging operations, the heavy center-punch marks are necessary. During forging

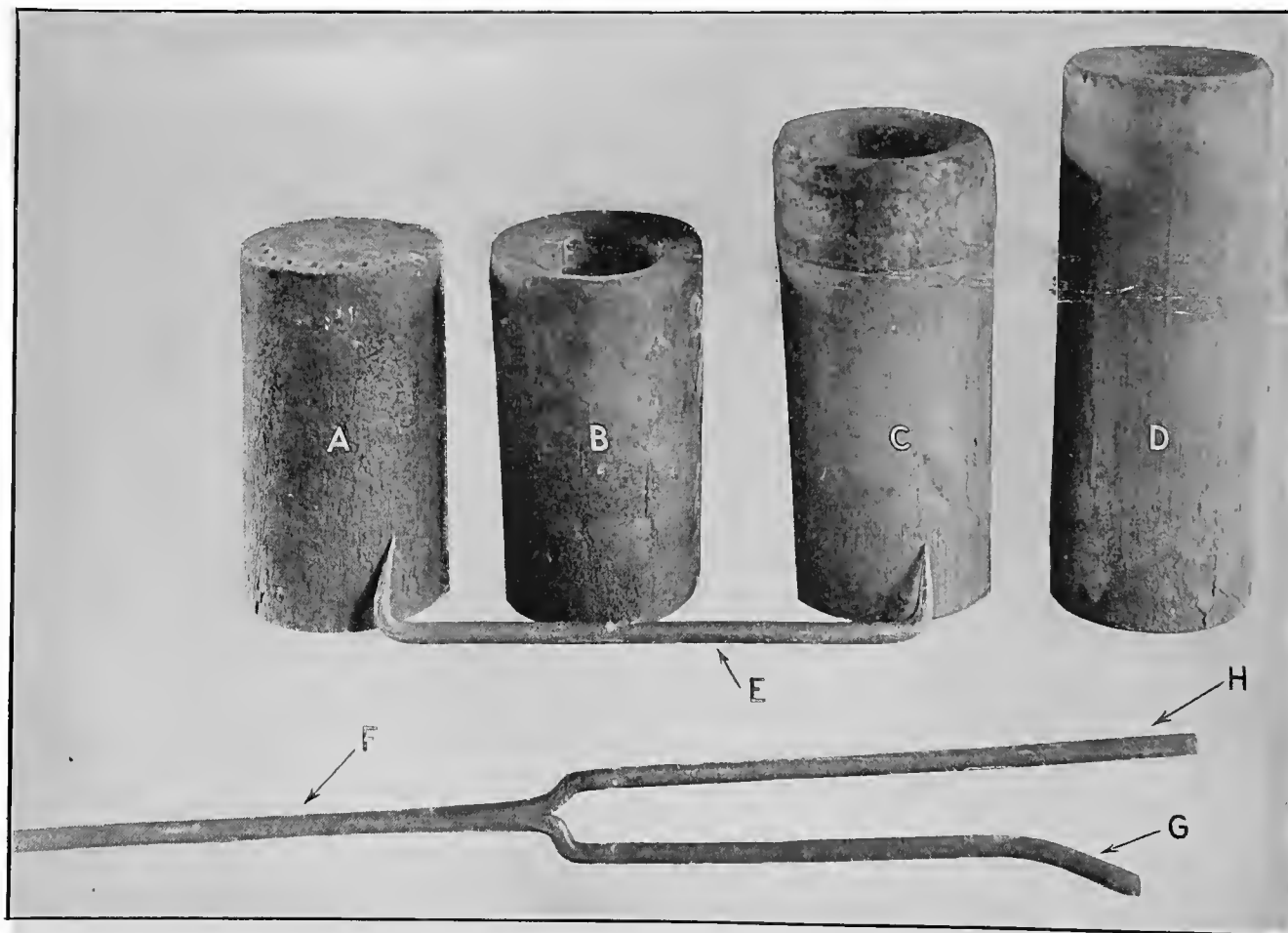


FIG. 1. FROM BLANK TO FINISHED FORGING WITH GAGES

is absolutely central there is only $\frac{3}{16}$ in. all around for finishing. Not only is there great difficulty in getting the hole central to start with, but with a punch $3\frac{1}{8}$ in. diameter and 22 in. long it is difficult, owing to the tendency to bend, to keep it central throughout the 11 inches of its traverse in the shell forging.

they are distorted, but they appear on the rim after the final forging operation and can be readily deciphered.

PIERCING

The first forging operation is piercing and this is done under a Bertram steam hammer with the tools shown.

The blanks *A*, Fig. 1, are placed with a scoop, Fig. 8, 25 or so at a time, in a reverberatory furnace. Oil at 30 lb. pressure, with air at 80 lb., is used for fuel. Once the furnace is hot, the blanks reach the forging temperature in about 45 minutes. Three men handle the piercing operation—one furnaceman, a hammerman and a blacksmith. When the blanks have reached a full yellow heat, the furnaceman takes a long iron hook and tumbles one out on the floor in front of the furnace. He then seizes it with a pair of pick-up tongs *A*, Fig. 2, and drops it into the die *B*, the hole in which is large enough to let it drop clear to the anvil face. He next takes the punch guide *C* and places it over the blank, as shown. The smith, in the meantime, has taken the punch *D* in a pair of pick-ups and entered it in the hole in the guide *C*. The hammerman, guided by a nod from the smith,

is then lowered so that the work within it rests on the steel disk. A single stroke of the hammer on the die top drives the die down past the work, and the disk forces the work into the large part of the tapered hole in the die. The furnaceman now turns the die over with the handles *G*, the finished first-operation blank drops out of the die and is picked up by the smith and thrown into an iron tote box.

One would imagine from the lengthy description that this is a long job. I timed the gang, unknown to them, on 20 pieces, and they averaged a piece per minute. But it is all work—the pieces weigh about 47 lb. each, and lifting this weight with a 4-ft. pair of pick-ups is a man's job. The movements made by the men were exactly duplicated on each piece except two that were a little too large to enter the die and had to be driven in

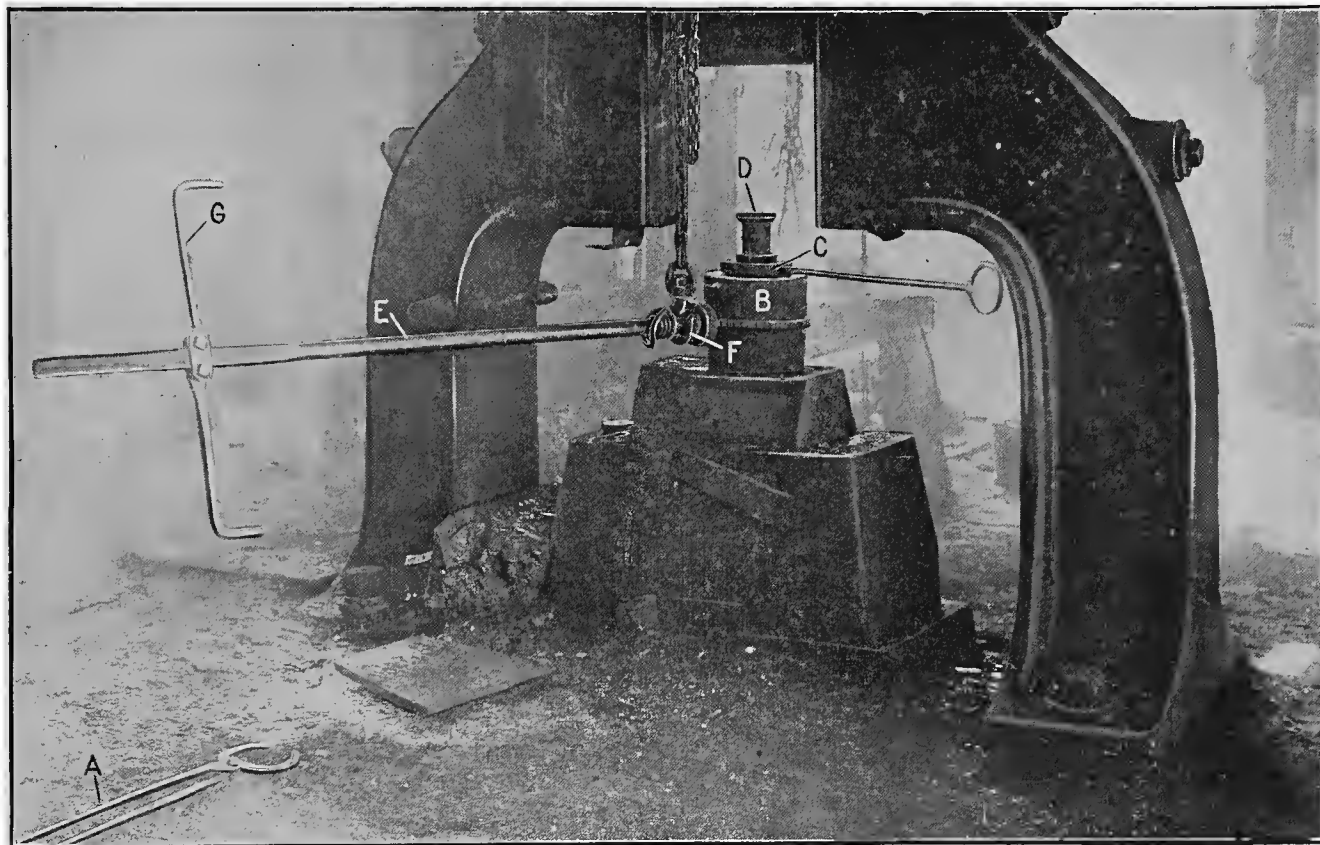


FIG. 2. FIRST OPERATION: PIERCING IN THE STEAM HAMMER

makes two or three strokes with the hammer. With the hammer in raised position the smith quickly removes the punch and plunges it for an instant in water. As the hole now started is capable of acting as a guide for the punch, the guide *C* is removed by the furnaceman and dropped in a tub of water. Just before the smith replaces the punch *D* in the hole in the work, the hammerman throws a pinch of soft-coal dust in ahead of it. Again guided by a nod from the smith, the hammerman strikes four or five blows. The gas generated from the coal dust, blowing out around the punch, prevents it sticking in the work. The punch is again removed and dropped in water. The furnaceman now presses down on the long die handle *E*, and as the chain-hoist hook *F* acts as a fulcrum, the die and work are lifted clear of the anvil. While thus raised, the hammerman places a steel disk about 4 in. diameter and 1 in. thick under the work in the die, which

by the hammer, using the guide *C* as a driver. After each heat the die and other tools are placed in water to cool, the furnace is recharged, and the men rest till the next heat is ready.

The die is a steel casting machined to the dimensions shown in Fig. 5 and will stand up for about two days before it has to be re-dressed inside. Re-dressing becomes necessary because of upsetting and getting smaller, not, as one would expect, because it gets larger. The punches, Fig. 6, are made of about 80-point carbon steel, and last from four to five days. They usually fail because of heavy checking on the extreme end. In Figs. 5, 6 and 7 reference letters are used to indicate dimensions that are correlated. The dimension *A*, Fig. 7, enters the dimension *A*, Fig. 5, centering the punch guide, Fig. 7, with the die, Fig. 5. The dimension *B*, Fig. 7, accommodates the top of the hot blank and centers it. The dimension *C*, Fig. 7,

acts as a guide for the dimension *C* of the punch, Fig. 6. The average output for a 24-hr. day is 500 pieces, but as high as 320 have been done in 10 hours. The work after the first operation is conical, measuring about 5¼ in. diameter at the top and 5 in. at the bottom. In length it is about 9 in., the same as the ingot blank, from which it was forged. The pierced hole is 3 in. diameter and about 4 in., more or less, in depth.

SECOND OPERATION

The second operation is in reality a further piercing operation to which is added the effect of squirting. The

in line with the knock-out hole in the center of the die block. The bar *D* is supported by the chains *E* secured to the upper platen.

The work for the second operation is heated in a furnace similar to that used for the first operation. It is, however, provided with an inclined chute down which the hot blanks roll as they are pulled from the furnace. The lower end of the chute is within easy reaching distance for the pressman. The operation is as follows: The furnaceman pulls a hot blank from the furnace with a long hook. A helper, grasping it with a pair of pick-ups, places it upright on a block of iron. After scraping the scale

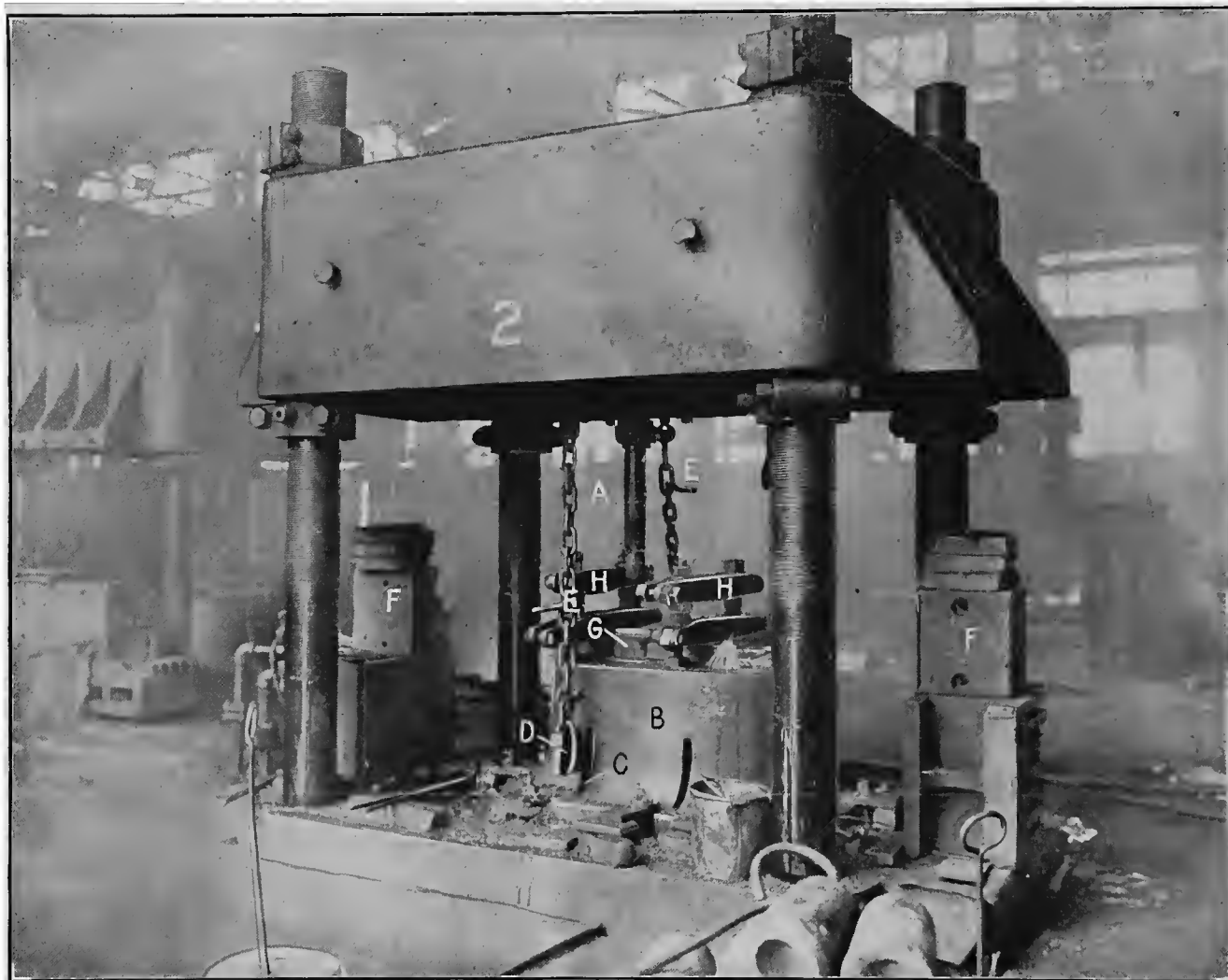


FIG. 3. SECOND OPERATION: SQUIRTING 4.5 SHELL BLANKS

metal displaced by the punch, following the line of least resistance, flows upward between the punch and die.

This operation is done on the 500-ton R. D. Wood flanging press shown in Fig. 3. The upper part of this press, carrying the punch *A*, is stationary, while the base, carrying the die holder *B*, moves. The die holder is a heavy iron casting with accommodation for two sets of dies, but at this writing one die only is used. The die is a steel casting made by the same concern that casts the blanks. It is machined as shown in Fig. 9. In the bottom is a countersunk hole to accommodate a 1¼-in. rivet that acts as a knock-out.

The arrangement of the knock-out mechanism is simple. The slot *C* passes clear through the die holder *B* and is

off, the helper picks it up again and drops it in the die, Fig. 3, which is about an inch deeper than the length of the first-operation work. He then opens the valve and the ram ascends. Just before the work reaches the punch, the smith in charge of the second operation throws a pinch of soft-coal dust in ahead of the punch. The work coming upward, strikes the punch and is pierced by it. Just before the completion of the stroke the excess of metal in the blank squirts upward about 3 in. around the punch. The gas generated from the coal dust bursts out in a jet of flame all around the punch and keeps it from sticking. The stroke of the plunger is positively controlled by the two piles of parallel blocks *F* coming in contact with the upper platen of the press. The ram is reversed, and the

die and work recede from the punch. When near the end of the downward travel of the ram, the chains *E* raise the bar *D*, which strikes the knock-out in the die and causes it to lift the work *G* and loosen it in the die. It is then readily removed with a pair of pick-ups and laid to one side. The stroke of the second-operation press is 20 in. This operation takes a little longer than the first, but an output of 500 pieces in 24 hours can be maintained.

These dies also are made from steel castings and have an average life of about 1000 pieces. The punches, Fig. 10, are made of the same steel as those for the first operation, and will stand up for about 500 pieces. They are secured in the upper platen by means of a nut passing over

3 in. at the bottom and $3\frac{1}{8}$ in. at the top. The base of the work at the completion of the second operation is $1\frac{1}{2}$ in. thick.

THIRD OPERATION

The third and last operation, the final drawing of the shell, is performed on an R. D. Wood 500-ton press similar in every particular to that used for the second operation. Owing to the length of the punch and work the stroke of the press is increased to 30 in. for this operation.

The punch *A*, Fig. 4, is mounted in the upper platen, as in the previous operation. The die holder *B* is bored centrally to receive two dies placed tandem, one above

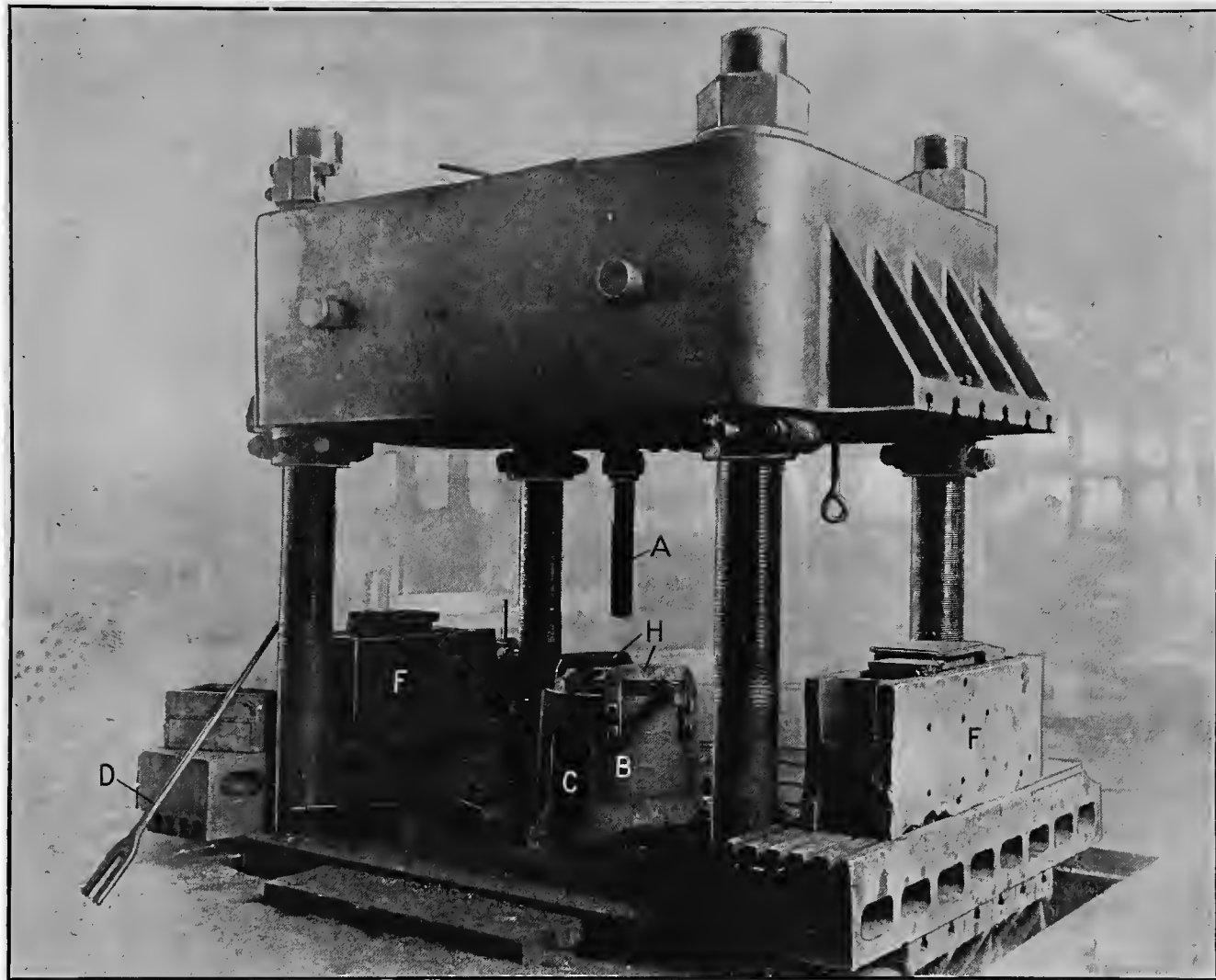


FIG. 4. FINAL DRAWING OPERATION ON 4.5-IN. SHELL FORGINGS

the body of the punch and clamping the flange to its seat in the upper platen. This type of fastening is common in plate-punching machines. Checking and bending are the principal troubles. The first is due to alternate heating and cooling with a water jet made from a piece of pipe bent to encircle the punch and perforated on the inside for the egress of the water. Bending is caused by imperfect centering of the depression in the first operation and unequal flow of the metal during the second. The work comes from the second operation, conical in shape, about $5\frac{1}{4}$ in. diameter at the top, 5 in. diameter at the bottom and about $11\frac{3}{4}$ in. high. The hole is tapered,

the other. The bored die seat communicates with the cored opening *C*, which is for the insertion of the forked stripper *D*, and the removal of the completed work.

Heating of the completed second-operation blanks for the final drawing is accomplished in a furnace similar to those used for the first and second operations. The hot blank, on being taken from the furnace, is first scraped to remove the outside scale. It is then placed mouth-up in the die. The valve being opened, the ram ascends. Just before the punch enters the work, the smith throws the usual pinch of soft coal into the hole. At the completion of the stroke the work, still clinging to the punch,

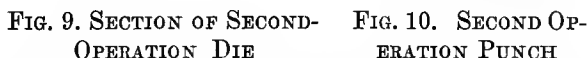
With the forging lying on its side, the leg G is inserted till it touches the bottom of the hole. The end of the leg

FIG. 5 FIRST OPERATION DIE

FIG. 6 FIRST OPERATION PUNCH



H should then be flush with the bottom on the outside, the difference in the lengths of *G* and *H* indicating 1½ in., the thickness of the base. The forgings are placed in a pile and allowed to cool slowly, so as to leave them

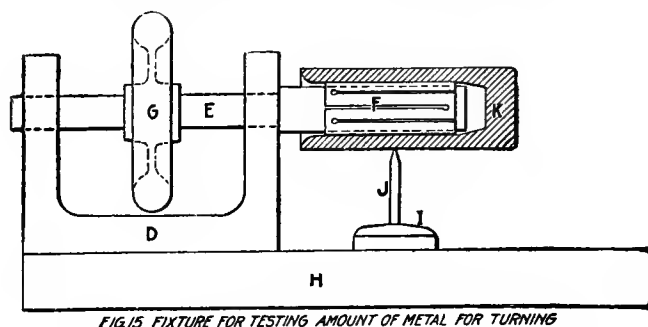


The flat steel straps *H*, Fig. 4, also indicated by the same reference letters in Fig. 3, can be used in conjunction with two flat bars as strippers, should the forked stripper for any reason fail and the work be drawn back through the dies.



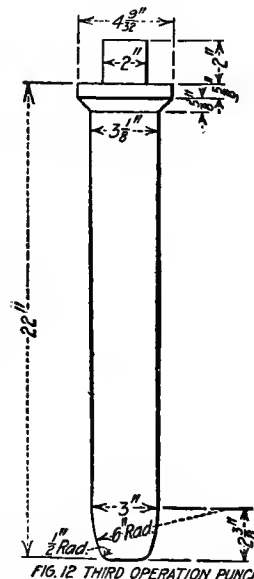
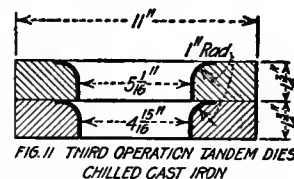
Diagram of Inspector's Overall Length Gage. It shows a U-shaped frame with a horizontal bar across the top. The bar is labeled $\frac{1}{2}$ " Round Steel. The frame has a vertical section on the left and a horizontal section on the right.

FIG. 13 INSPECTOR'S OVERALL LENGTH GAGE



FIGS. 13 TO 15. DETAILS OF TESTING DEVICES

fail by wearing out, that is, becoming too large, so that they do not draw the shell long enough. It will be noted by referring to Fig. 11 that the upper die is $\frac{1}{8}$ in. larger in diameter than the bottom one. When the latter wears too large it is re-dressed by grinding and used as an upper die. The punches, Fig. 12, are made of the same steel as those for the previous operations and average about 500 pieces; in one instance 5000 were produced with a single punch. They fail principally through bending, which is difficult to offset. Care in centering the blank properly in the dies is of considerable assistance in keeping the punches straight.



FIGS. 11 AND 12. THIRD
OPERATION PUNCH
AND DIES

After the forgings have cooled they are taken to the government inspection tables, which are equipped with the inspection appliances shown in Figs. 13, 14 and 15. The forging is first inspected for overall length with the gage, Fig. 13, also shown at *E*, Fig. 1. Next, the thickness of the base is tested with the gage, Fig. 14, which is similar to, but shorter than, the smith's gage shown at *F*, Fig. 1. The relation of the hole to the outside and whether the forging will "clean up" are

The head *D* carries a spindle *E*, the nose of which is tapered to receive the expanding sleeve *F*, which fits in the hole in the forging *K*, shown in section. A hand-wheel *G* provides means for rotating the spindle and work. The head *D* is bolted to a flat piece of boiler plate *H*,

which is sufficiently accurate for this work. The height gage *I* is provided with a hardened fixed indicator *J*. Inspection consists of sliding the forging *K* on the expanding mandrel *F*. While rotating it with the handwheel *G*, the height gage *I* is slid on the plate *H*, the hardened end of *J* coming in contact with the forging at various points. So long as the height gage will not pass under *K* at any point, the forging will clean up. Should it pass under, the forging is condemned. Having passed inspection, the forgings are loaded on cars and shipped to the machine shop.

Shell-Socket Assembling Tool

BY GEORGE ARMSTRONG

The accompanying illustration, Fig. 1, shows the general arrangement of a brass-socket assembling tool used in the manufacture of the 18-lb. British shells. Details are given in Fig. 2 and full instructions as to its use follow:

To screw in the partly finished socket, screw the center plug *A* through the outer nut *B* until it rests against the pin *C*. Then screw the plug into the socket *E*, turning *A* right-handed. When it bottoms in the socket turn back

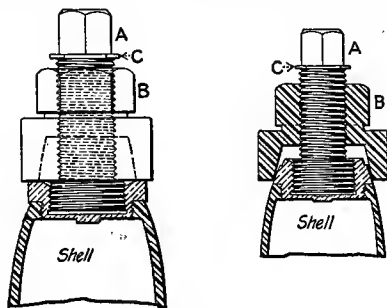
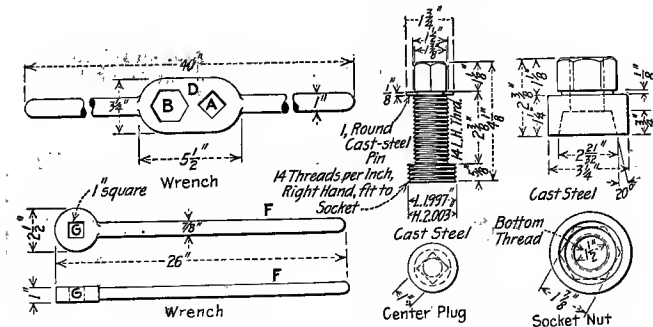


FIG. 1. GENERAL ARRANGEMENT OF SHELL-SOCKET ASSEMBLING TOOL

the plug *A* about two threads, and then turn the nut *B* left-handed until it rests on top of the socket *E*. Thus the socket is gripped by both the plug and the nut. Now place the wrench *D* on *A* and turn right-handed. By the action of the right- and left-hand threads the socket can be screwed down tightly without injuring it in the least.

To release the tool from the socket place the wrench *D*



Continuous Sawing and Facing on Planer-Type Millers

By E. A. SUVERKROP

SYNOPSIS—What is virtually a continuous method of sawing forging blanks for shells from bar stock and face-milling the bases of shell forgings on planer-type millers has been developed at the Montreal Locomotive Works, Ltd., Longue Pointe, Montreal, Quebec.

In Fig. 1 is shown a method that has recently been developed and installed at the Montreal Locomotive Works, for sawing forging-blanks for shells. The machine is a heavy Bement slab miller with a table 14 ft. long by 42 in. wide. Details of the saw arbor, which carries

seven 20-in. saws, are given in Fig. 2. The details of the work-holding fixture appear in Fig. 3.

The bars are first cut in a heavy turret lathe into $42\frac{1}{8}$ -in. lengths. Allowing seven kerfs $\frac{3}{8}$ in. wide, this gives 8 forging blanks, $4\frac{7}{8}$ in. long, per bar. The jig accommodates 32 bars. A man and a helper operate the machine. When the cut has advanced about half way, the parted blanks are removed and other bars set—all this with the machine in operation. On the completion of the traverse the saws are elevated, the table returned at high speed and the cut started again on the replaced bars. The operator and helper then remove the cut blanks from the forward half of the jig and recharge with bars.

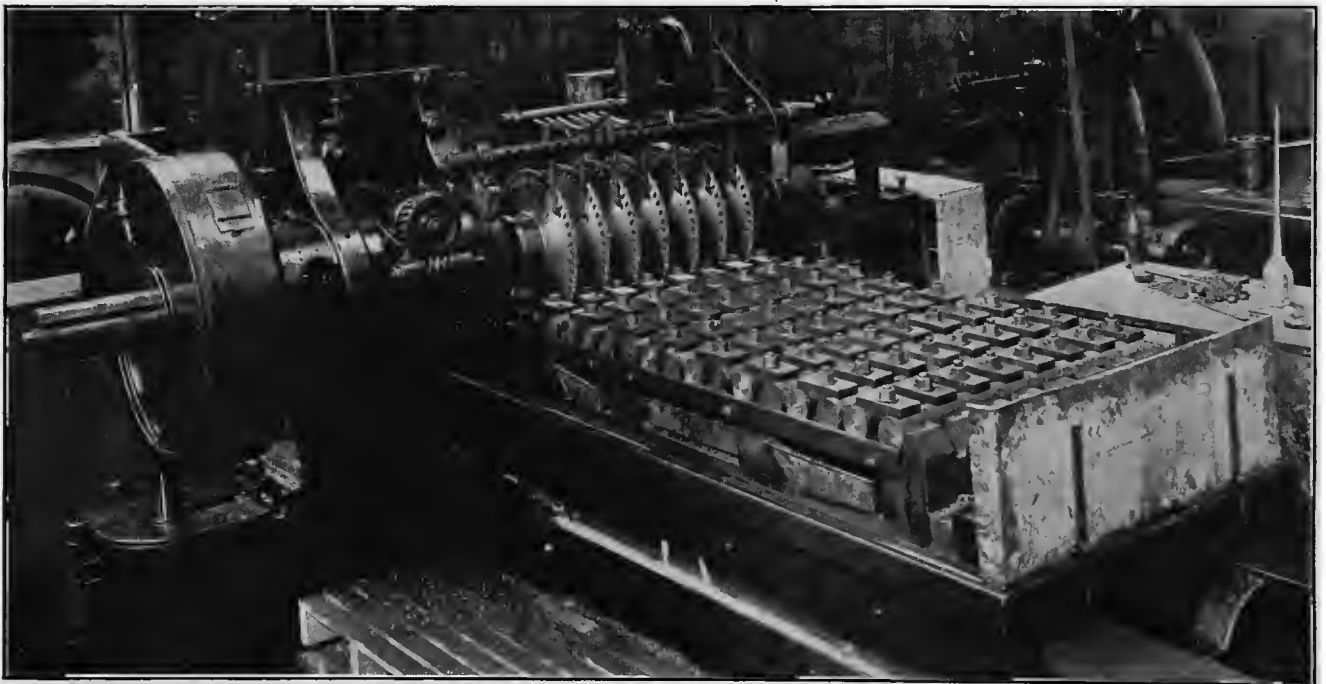


FIG. 1. BEMENT MILLER SAWING 672 FORGING-BLANKS IN 10 HR.



FIG. 4. FRONT OF FACE-MILLING FIXTURE

The Disston inserted-tooth saws, seven in number, are 20 in diameter. The teeth are $\frac{7}{8}$ in. wide.

An Ingersoll miller is also equipped with a fixture of this type, but the arbor carries only six saws.

On the Bement machine 672 blanks can be cut in 10 hr. During the night shift, 13 hr., 768 blanks can be

clamp both ends of 17 forgings. To resist the high stresses set up by tightening the screws, the partitions between the pockets are necessary. The pockets divide the work into independent groups, permitting them to be emptied and charged separately, through which arrangement the machining operation can be made continuous.

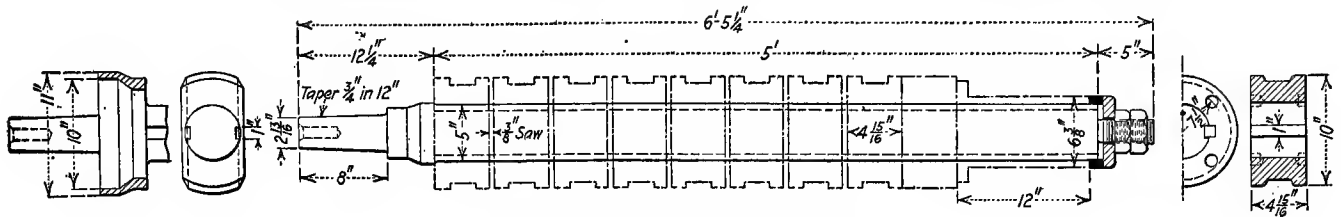


FIG. 2. DETAIL OF SAW ARBOR

cut. To traverse the entire length of the table takes 4 hr.

FACE-MILLING SHELL BASES

The fixture shown in Figs. 4, 5 and 6 holds seventeen 3.3-in. shell forgings in each pocket, or 85 in all. The

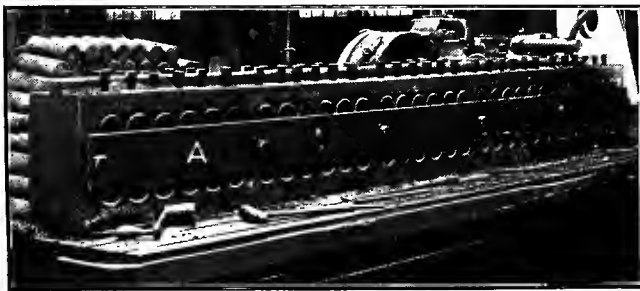


FIG. 5. REAR OF FIXTURE SHOWING PLATE-STOP

amount of stock to be removed varies from about $\frac{1}{4}$ in. up to $\frac{3}{4}$ in. The cut takes 1 hr. 15 min. to traverse the entire length of the jig. The cutter is 12 in. diameter, with 24 inserted teeth. The body of the cutter is of steel. On an average the cutters with one grinding

The detail, Fig. 6, gives all the necessary dimensions. The plate A, Fig. 5, acts as a stop for the hollow end of the shell blanks. These are cut off a positive distance from the inside of the base, before going to the face-milling operation.

Skilled Labor in England—It is pointed out by our London editor that the return of the combatants, though not necessarily a simultaneous action, will itself have a disturbing effect, while the present influx of semiskilled men employed owing to the pressure for munitions is another matter. The method of training lads for the engineering trades is still

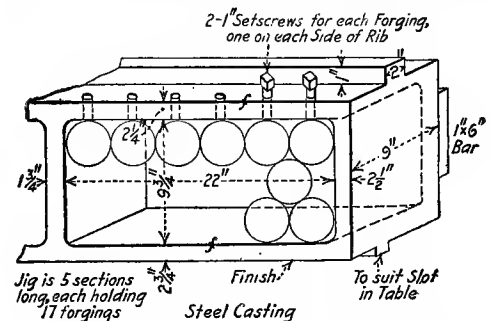


FIG. 6. DETAIL OF SHELL-FACING JIG

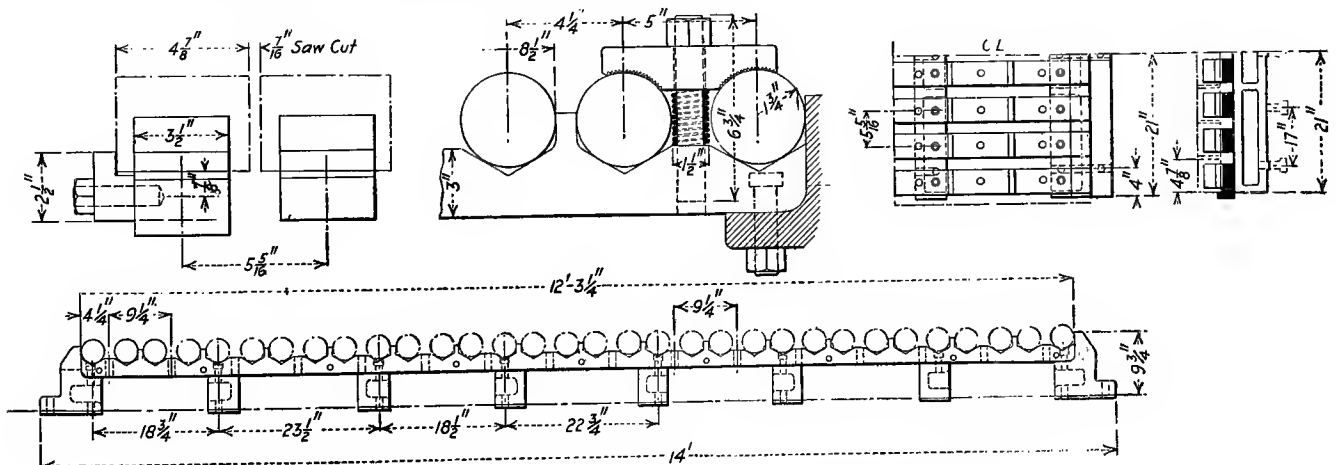


FIG. 3. DETAILS OF THE WORK-HOLDING FIXTURE

will stand up for 10 hours' practically constant work. The operation is similar to that described for the cutting off—when the work is finished in one part of the jig, it is removed and replaced with rough forgings without stopping the machine.

The body of the fixture is a steel casting. The method of clamping is interesting. Twelve setscrews securely

largely to employ them on such jobs as they are capable of undertaking, gradually increasing the difficulty of the job. In certain instances the method can be fairly severely criticised in ordinary peace times, but in these days when engineering skill of any kind is in demand mainly, perhaps almost entirely, for production of work of repetition character, there is certainly much less chance for the individual lad to obtain that variety of jobs which will insure that he shall be a reasonably skilled workman after a few years of experience.

Forging Base-Plates for Lyddite and High-Explosive Shells

By E. A. SUVERKROP

SYNOPSIS—Pipes in the bases of shells are always a possibility. To prevent the flame from the propulsive charge traversing such possible pipe and detonating the explosive charge prematurely, the bases of all high-explosive shells are recessed and fitted with a base-plate. The grain of the metal in these is at right angles to the axis of the shell, and they securely seal any pipe or fissure.

No matter by what process bar steel is produced there is a possibility of piping and seams. The blanks for common lyddite and high-explosive shells are forged from bar stock. Should a pipe exist in one of the original blanks made from either cast bar-billets or rolled bar-stock it is almost certain to be in the forged blank. With ordinary British shrapnel this is of no consequence, as the explosive charge is contained in a metal receptacle—the cup—and there is no chance of the flame from the propulsive charge communicating with it by way of a pipe.

With the explosive shell conditions are different. The hollow body of the shell itself acts as a container for the explosive charge, and should there be a pipe in the shell base, there is immediate connection between the propulsive and explosive charges. The flame from the propulsive charge traversing such connection would detonate the explosive charge and cause the destruction of the gun and probably of all the men near it.

In order to prevent such possible disaster the high-explosive shell has a bored and threaded recess in the center of the base on the outside, to receive a base-plate forged

or fissure, should one exist, and prevents premature explosion of the charge contained in the shell.

In the Turcot shops of the Canadian Car & Foundry Co. the blanks for base-plate for 4.5- and 5-in. high-explosive shells are made on an Acme forging machine,

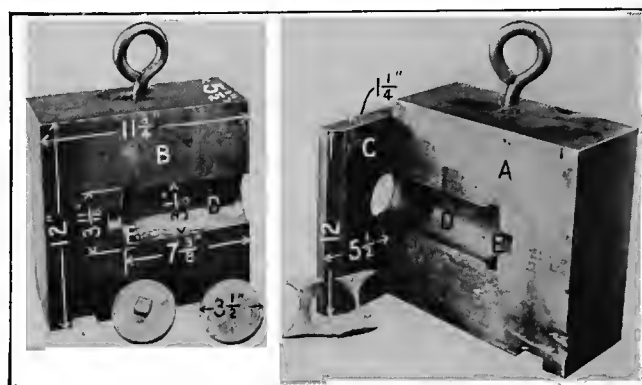


FIG. 2. THE WORK DIES AND SCRAP

shown at A in Fig. 1. The dies, two disks and the scrap are shown at B.

The stock used is 1x3-in. cut in 3-ft. lengths, which weigh about 27 lb. These bars are heated four at a time in an oil-fired furnace, shown at C.

THE FORGING OPERATION

The machine is rather awkward for the forging work, as the operator must grip a bar in his tongs, run up the steps and insert the end vertically in the dies.



FIG. 1. FURNACE AND FORGING MACHINE

from flat steel. The grain of the metal in the base-plate therefore runs at right angles to the axis of the shell. The base-plate is accurately machined to fit the threaded hole, is screwed and riveted in place, and finally turned flush with the base of the shell. It thus securely seals any pipe

An enlarged view of the dies, work and scrap appear in Fig. 2. The die A, Fig. 2, is fixed, while B is mounted in the movable slide. The hot bar is fed down past the blanking die C secured to the face of A. The die B advances until it strikes the face of A, where it dwells

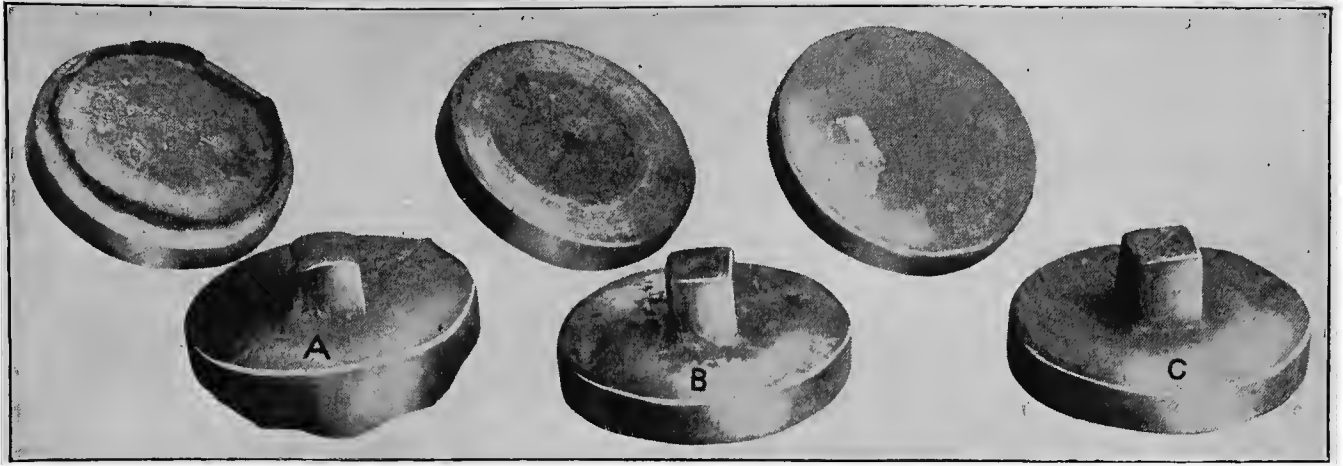


FIG. 3. THREE STAGES IN THE PRODUCTION OF BASE-PLATES

till the advancing punch, not shown, blanks a disk through the hole in *C*, pushes it along the tubular opening *D*, and squeezes it into the form *E* at the end of the stroke. On the completion of the stroke the punch and the die *B* recede and the forged base-plate is removed with a pair

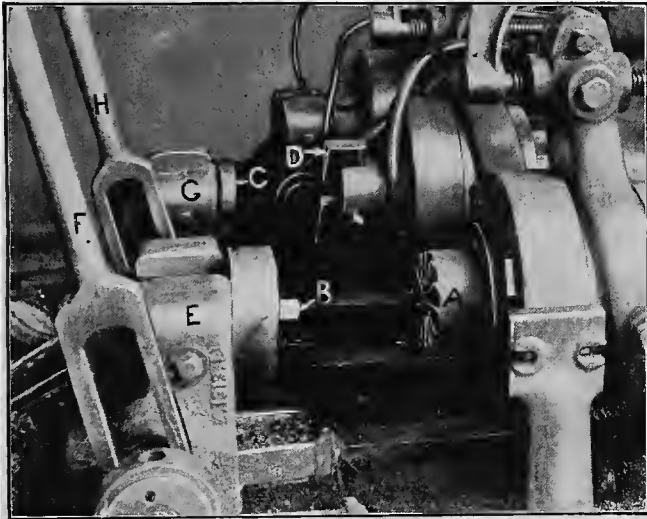


FIG. 4. REMOVING FINS ON BOLT THREADER

of tongs from the die. Two men can forge 2000 of these base-plate blanks in 24 hr.

The forgings as they come from the machine are rather rough and would average as shown at *A*, Fig. 3. The fins are of course caused by necessary clearances between the dies and the punch.

The machine shown in Fig. 4 is an old bolt threader that is used for removing the fins. Two only of the three heads of the machine are used. An end mill, with a hole for the passage of the square shank *B*, is used to remove the fin from the back of the base-plate. The latter is gripped in a shallow cup chuck, held in the bolt vise *E*. Two setscrews prevent it from turning. The work is advanced to the cutter by the lever *F*.

After the fins are removed from the back the work *C* is gripped by the square in the bolt jaws of the vise *G*, so that the fins can be removed from the front, with the facing cutter *D*, the vise *G* being advanced by the lever *H*. Two men can remove the fins from 1200 base plates in 24 hr. The work then appears as shown at *B* in Fig. 3.

INSPECTION OF THE WORK

From the bolt cutter the work goes to the inspection tables, where the gages shown in Figs. 5, 6 and 7 are used. The captions indicate their application to the work, therefore no further description of the inspection operation is necessary.

Here and there an occasional base-plate fails to pass the visual inspection, the principal cause being scale or a depression in the center of the face. Such base-plates are restruck.

RESTRIKING IMPERFECT WORK

The work that fails to pass inspection is heated in the furnace *B*, Fig. 8. The operator takes the hot base-plate in a pair of tongs, dips it for an instant in cold water, which causes the scale to break and fall off, and places it with the shank in the square hole in the die *A*.

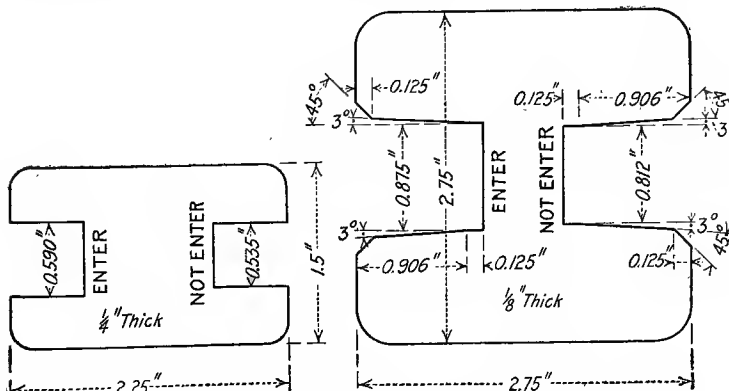


FIG. 5. GAGE FOR FORGING THICKNESS

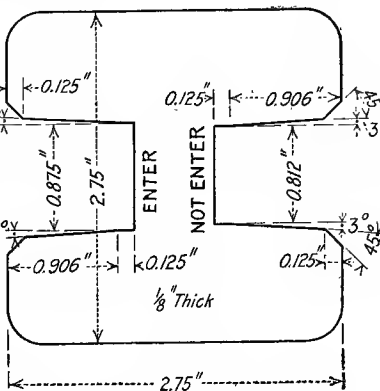


FIG. 6. GAGE FOR SHAPE AND SIZE OF HEAD

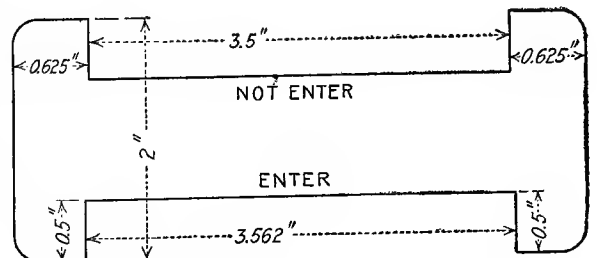


FIG. 7. GAGE USED FOR DIAMETER OF THE FORGING

His helper holds the die between the members *C* and *D* with the face of the work toward the moving member *C*. When the machine is tripped *C* strikes the face of work and the rear end of the die *A* brings up against the metal

the men at the arsenal worked strictly by the day. It was not long before it became known to all of us that while we were filing on the average twenty-five sides each per day, and not earning extravagant wages at that, the men

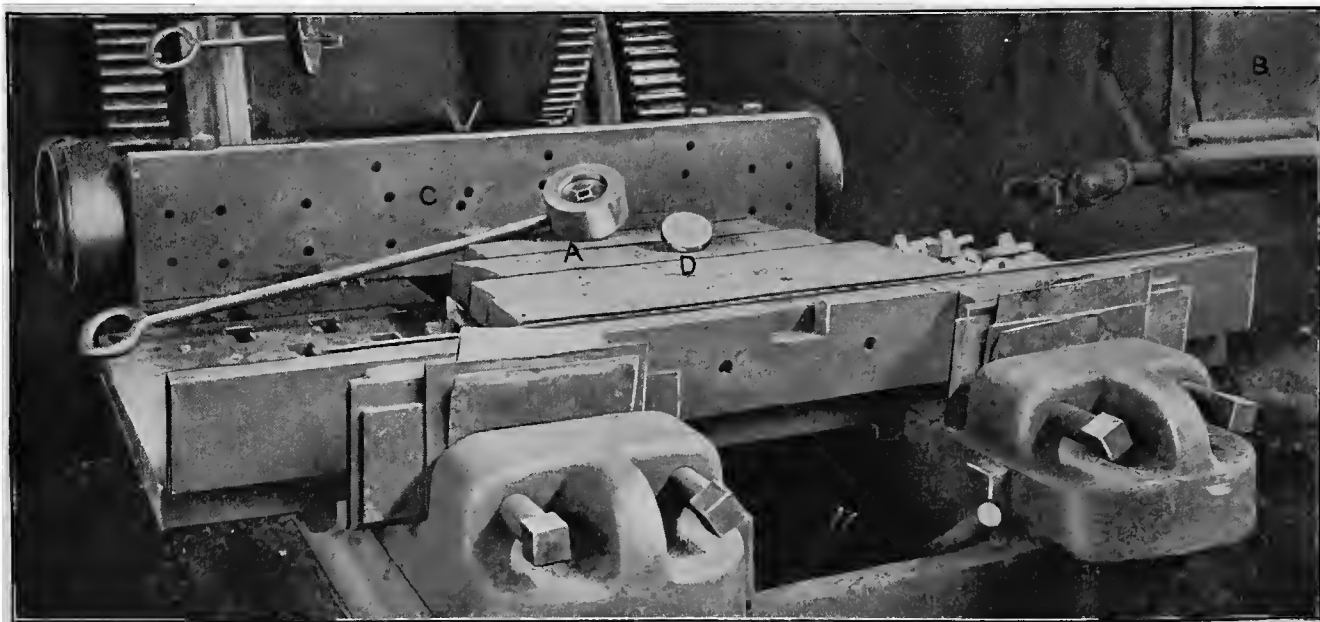


FIG. 8. RESTRIKING DIE AND BULLDOZER

blocking *D*. The work comes from the restriking die as shown at *C*, Fig. 3, practically without scale, and as there are no joints or fissures in the die there are no fins to be removed.

Inspection of War Material

BY TECUMSEH SWIFT

The events of these days are to me provocative of reminiscences of the time of the Civil War. It is known well enough by everybody that many establishments in the United States are now busily employed in the manufacture of various war material, and in connection with such manufacture we are hearing interesting stories about the peculiar insistencies of some of the inspectors who have to examine and pass on the output before shipment.

This is not at all new to me. It happened, now more than fifty years ago, that I was employed on war material almost throughout the entire period of the Civil War in one of the largest machine shops in the state outside of New York City (which then boasted a number of large marine-engine works, which, as, for instance, the Novelty Works, did a wide variety of other work), and in this shop I consequently had my experiences. Our work in this shop at the beginning of the war was in the way of assisting in the manufacturing operations of the Watervliet Arsenal. The work at this arsenal in the ante-bellum days had been the manufacture of harness and horse equipment, and naturally the activities there at the beginning of the war were continued in the same line. The work that came to us first, then, was the making of bits for artillery horses, and later also for cavalry. The sides of these bits were drop-forgings, and they were to be filed all over previous to tinning. The filing of these bit-sides employed a great many men, both at the arsenal and at our shop. Our work was on a piecework basis, while

in the arsenal were filing only two sets per day, with a general understanding that if anyone should file three in a day he would be in danger of being discharged for slighting his work. That was the scientific management of the period.

This arrangement came to an end after a time. The inspector of the sides at our shop was an old and superannuated regular army sergeant, absolutely honest, I believe, but with unlimited capacity for finding fault, and as there were no gages or standards to refer this work to, it all depended upon his judgment, of which he had plenty—such as it was.

INSPECTING BIT SIDES

I was sent one day to assist him by stamping the sides with his mark as fast as he examined them. He would hand them to me, frequently with some remark as to the file streaks not all running the same way, or something of that sort, and I would stamp them all as fast as I received them. It turned out after a time that whenever he had made a remark to me it was meant as a rejection of the piece, and when he "caught on" to what I had been doing the inspection came to an end at once. He told his story to the arsenal authorities and then a new arrangement was made. After that our filing was all done by day work, with never a hint allowed with reference to hurrying up on the job, and the shop proprietors were paid a liberal percentage upon all the wages. Of course not half as much work was done, and none of it was done any better, but it all passed, as there was then a different inspector.

Then we got into the making of shot and shell—all cast iron, 2-in. solid shot, 24-pounder, 32-pounder, 8-in., 10-in., 13-in. and 15-in. shell. The 13-in. and the 15-in. shells, we understood, were to be used for battering fortifications, and were not considered to have the function of regular explosive shell.

Manufacturing British 4.5 High-Explosive Shells--I*

BY E. A. SUVERKROP

SYNOPSIS—In these, the first authentic articles on the manufacture of the British 4.5 high-explosive shell, each operation in sequence is described in detail. The illustrations include not only the usual halftone reproductions of machines, tools and operations under working conditions, but also line engravings from shop drawings of special machines, alterations to machines, jigs, fixtures, gages, and other appliances. In their entirety these articles form a comprehensive treatise on the manufacture of the British 4.5 Mark V high-explosive howitzer shell.

There is considerable difference between working out the manufacturing methods for an absolutely new job and copying or improving on methods already in use. How

mapped out manufacturing methods; conducted the necessary experimental work, and delivered a satisfactory sample shell to the Quebec Arsenal—all in two months—makes a story of mechanical accomplishment that should interest even those who are opposed to the manufacture of war material.

In Fig. 1 are shown samples from each stage of manufacture up to, but not including, the final operation of turning the copper band, which will be shown later in the series.

EXPERIMENTAL WORK ON THE BLANKS

The British Government requires that the 4.5 shell shall be made from steel forgings. The manufacture of these and the castings from which they are made has been covered in the articles beginning on page 1021, Vol. 42, and page 1, Vol. 43, respectively.

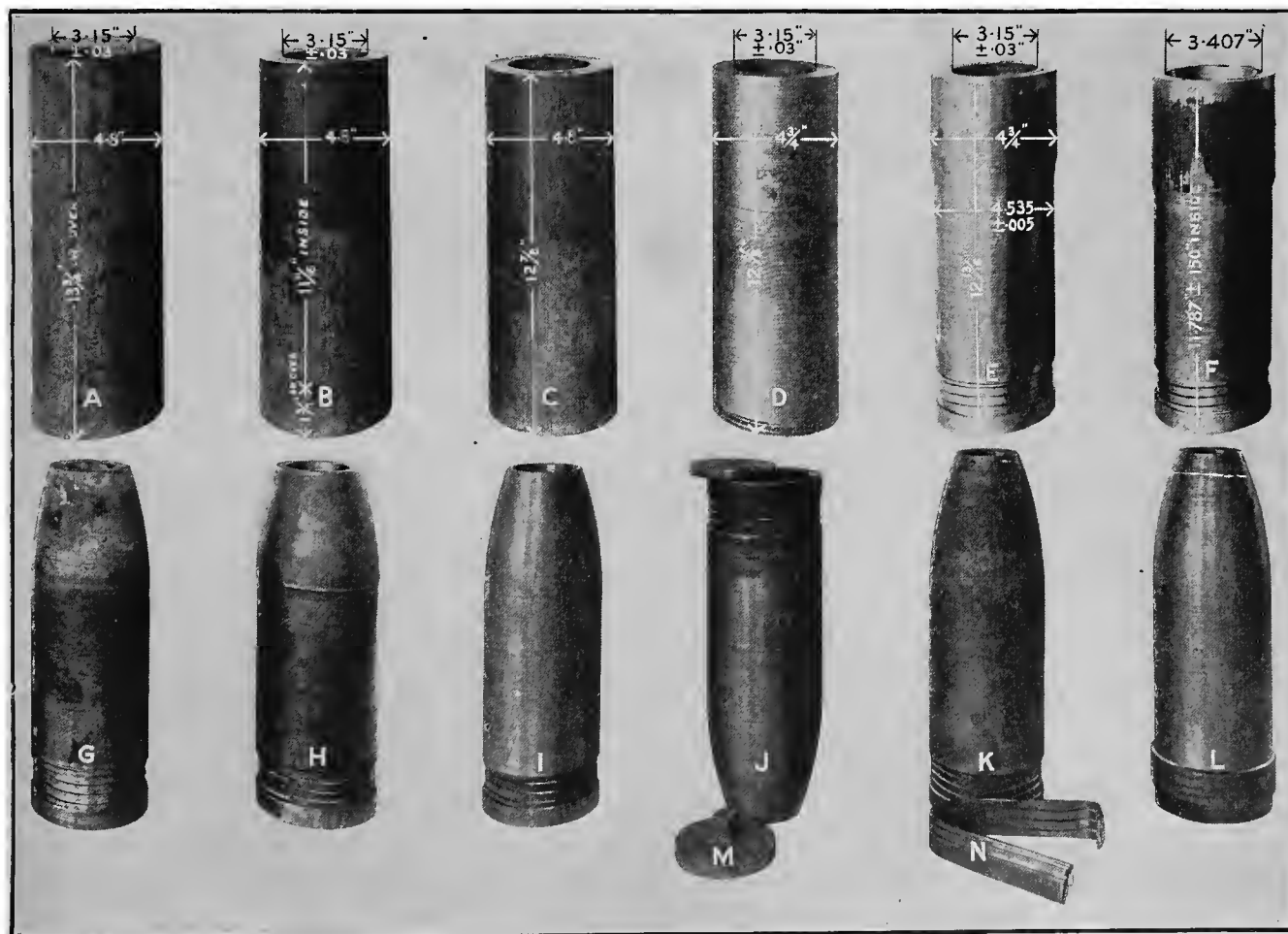


FIG. 1. PROGRESSIVE STAGES IN THE MANUFACTURE OF A 4.5 HIGH-EXPLOSIVE SHELL

Mr. Lynch, superintendent, and Mr. Sherry, general foreman, on Apr. 15 opened up the shops of the Canadian Allis-Chalmers Co. (which had been shut down since the previous September); overhauled the entire plant; bought, designed and built new tools, jigs and fixtures;

After turning and boring the forged blank must be nosed, that is, closed in at the end by a die. Experimental work is necessary to ascertain the exact shape and dimensions to which the blank must be machined, so that when it comes from the nosing die there is sufficient metal to assure cleaning up both inside and out. There must be no great excess of metal, for it is obviously cheaper and

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quicker to remove metal from a plain cylinder or cylindrical hole than to do form-turning or form-boring after the shell is nosed.

When the first of these 4.5 shells was made the government standard for the weight of the finished empty projectile was 26 lb. 14 oz. $\pm$ 1 oz. The allowance has since

NOTE: The head is to be concentric with the true longitudinal axis of body within a limit of 0.025"

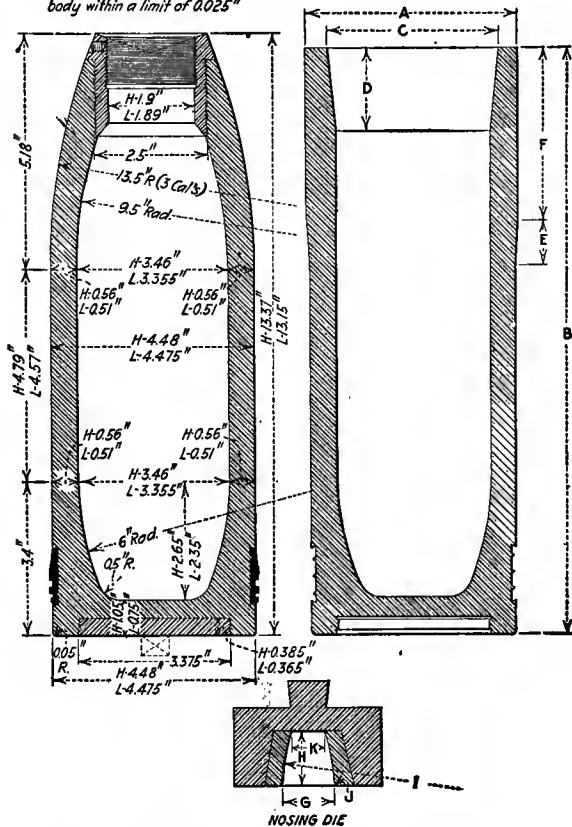


FIG 2. EXPERIMENTS ON NOSING 4.5 HIGH-EXPLOSIVE SHELL

A in.	B in.	C in.	D in.	E in.	F in.	Remarks
4 1/2	12 1/2	...	...	...	...	1st shell-dimensions of die were 4 1/2 in. at G, 3 in. at H and 3 in. at K. Shell after being nosed was too small half way up the nose.
4 1/2	12 1/2	3 1/2	1 1/2	...	...	2nd shell die was changed to 4 1/2 in. at G, 3 in. at H and 1 1/2 in. Rad. at I. After nosing shell was 1/2 in. shorter and upset at the end. This shell was cupped out at points C and D.
4 1/2	12 1/2	3 1/2	1 1/2	1	2 1/2	3rd shell was 1/2 in. shorter. When taken out of hammer had not enough metal on the outside for cleaning up same die as 2nd shell.
4 1/2	12 1/2	3 1/2	1 1/2	...	...	4th shell decided to change die to 4 1/2 in. at G, 1/2 in. at J, 4 1/2 in. at H, with the same Rad. as the finished shell. Shell was 1/2 in. shorter than before. Nosing was about 1/2 in. off. Nose about right on outside.
4 1/2	12 1/2	3 1/2	1	1/2	3 1/2	5th shell die was changed to 4 1/2 in. at G, 1/2 in. at J, 4 1/2 in. at H, 3 1/2 in. at K with 1 1/2 in. Rad. at I. This shell cleaned up but had too much metal on the inside to be removed. Same dimensions as 4th shell.
4 1/2	12 1/2	3 1/2	1	1/2	3 1/2	6th shell made to these dimensions using the same die as on shell No. 5. After being nosed had just enough metal left on the inside and outside for cleaning up. This shell was correct.

been raised to two ounces. The former requirement figures out to an allowance of a little less than 0.5 per cent., which is little enough when a cut 0.001 in. off the outside of the 4.5-in. blank will make a difference of 1/20 lb. in the weight.

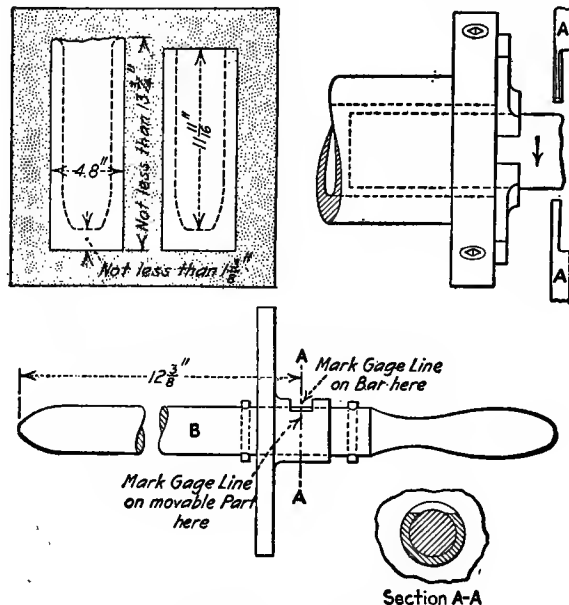
As the shape of the nose was the determining factor, the nosing die was the first tool to be made. No matter

what anyone may say to the contrary, almost every job requiring forming dies for its manufacture, in whole or in part, must be worked out by the cut-and-try method. The ability to figure is doubtless of great assistance, but in die work the metal never does exactly what one figures it ought.

The whole of the experimental work is very plainly set forth in Fig. 2, which gives the various changes made in both the work and the die before the correct shape of both was determined.

CUTTING OFF THE ROUGH FORGINGS

The forged blanks at this writing are made by another concern, but will later be made at the works, as three 350-ton and six 200-ton R. D. Wood hydraulic presses with



OPERATION 1: CUTOFF

Machines Used—Davis cutting-off machines with front and back tools A
Special Fixtures and Tools—None
Gages—Depth gage B or gage which forms part of the machine
Production from one machine and operator, 20 per hr.
Note—Soap water to lubricate the cut
Reference—See Fig. 3

furnaces are now being installed in the forge department for producing blanks for both 4.5-in. and "60-pounder" high-explosive shells.

The first operation is cutting off. The rough forgings are 13 3/4 in. (or over) in length over all. These go to the Davis cutting-off machines, one of which is shown in Fig. 3. The machine is provided with a gage rod A, which is rigidly set in the bracket B by means of a set-screw. The bracket B slides on the lower rod held in the machine frame. An adjustable sliding stop C limits the travel of the bracket B on the lower rod.

There is considerable difference in the thicknesses of the bases of the forgings. The minimum allowance here is 1 3/8 in., but some forgings have bases over 2 in. in thickness. It is obviously easier to machine the excess metal from the outside rather than from the inside, where there is difficulty in getting rid of the chips and preventing them from crowding the cut. For this reason the gaging of the forgings in the cutting-off operation is done from the inside of the base outward toward the mouth. Two methods of gaging are available—the gage rod A previously referred to and the hand gage shown at B

in the first-operation sheet. The latter is more accurate and less cumbersome to handle than the other; its operation is obvious. The machine gage is operated as follows:

The gage rod *A* is swung forward and entered into the hole in the forging, the face of the bracket *B* coming in

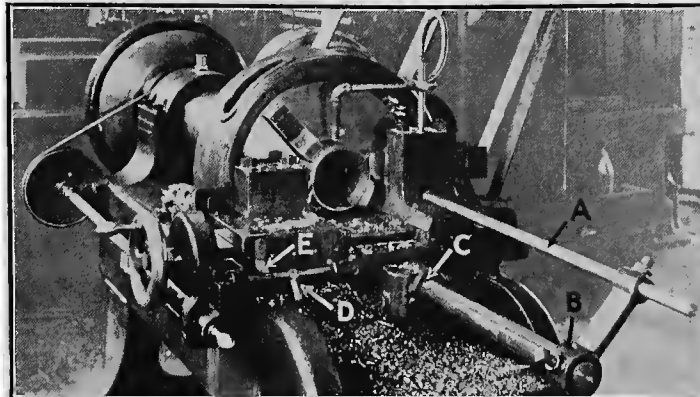


FIG. 3. CUTTING OFF MOUTH END OF FORGING

contact with the stop *C*. The forging is next pulled forward till the extreme end of *A* strikes the bottom of the hole. The chuck is then tightened and the machine started. Two tools are used, an angular one at the back to break the chip for the front tool. The distance from the bottom of the hole to the cutting-off tool is $11\frac{1}{8}$ in. Each machine can cut off about 20 forgings an hour.

The feed of the machine is by hand or automatic by means of worm and gear. The worm is held to its work by the latch rod *D*, which is released by the trip *E* when the work is parted.

FACING THE OUTSIDE OF THE BASE

The next operation is facing the outside of the base. This is done on the 8-ft. Bertram boring mill shown in Fig. 4. Details of the fixture used are shown in Fig. 5 and also in the second-operation sheet. A new type of

is held by the clamps *B*. To prevent the pins being damaged by dropping the 45-lb. forgings on them, the men, when loading, lay a piece of wood on the table next the pins to take the impact. Four tools are used, two in each holder. The feed is toward the center. Be-

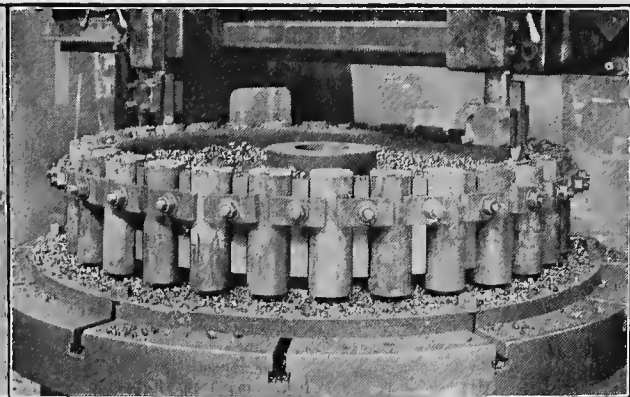


FIG. 4. FACING BASE ENDS OF FORGINGS

cause of the lack of uniformity in the forgings, as previously stated, the amount of stock to be removed varies from a mere scrape to $\frac{3}{4}$ in. depth.

With work of this character the ordinary tool holder is very inefficient by reason of the continual jolting as

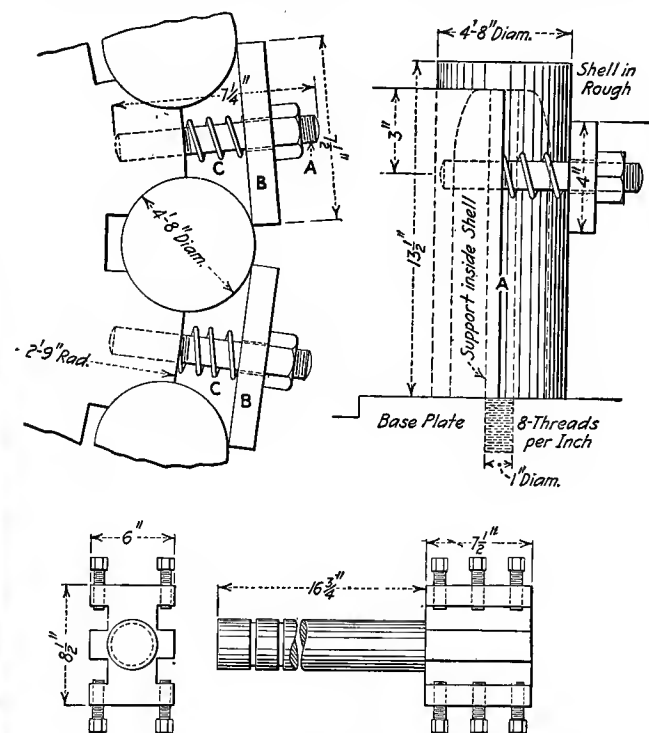


FIG. 5. FACING JIG AND TOOL HOLDER FOR BORING MILL

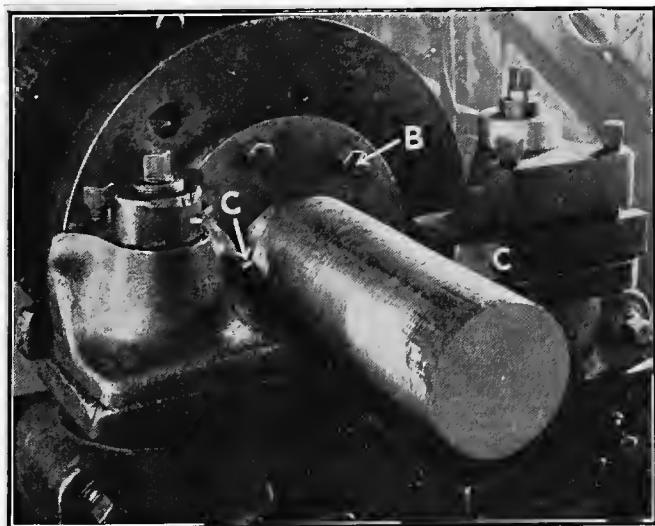


FIG. 6. ROUGH TURNING OUTSIDE OF SHELL

tool holder, not used when the photograph for Fig. 4 was taken, is now in operation.

The jig holds 30 forgings. The same locating point, the inside of the base, is used in this operation as in the previous one. The work rests on the pins *A*, Fig. 5, and

the tool passes from piece to piece. To overcome this difficulty a tool holder was made as shown in detail in Fig. 5. The tools in this holder are so spaced, one behind the other, that one of them is always in the cut.

An entire fixture full, 30 pieces, can be faced off in one hour. The operator gages the depth of cut of the lowest, or finishing, tool from the upper face of the jig. The work comes from this operation $12\frac{7}{8}$ in. long outside.

The shell is now rough-turned on the outside in the lathe. In Fig. 6 is shown a typical set-up for this job.

The shell is held on an expanding mandrel, as shown in detail in Fig. 7 and the third-operation sheet. It is driven by the collar driving dog B.

Two tools C, one at the front and one at the back, are arranged as shown in Fig. 6. The front tool starts its cut at the middle of the forging, while the one at the back

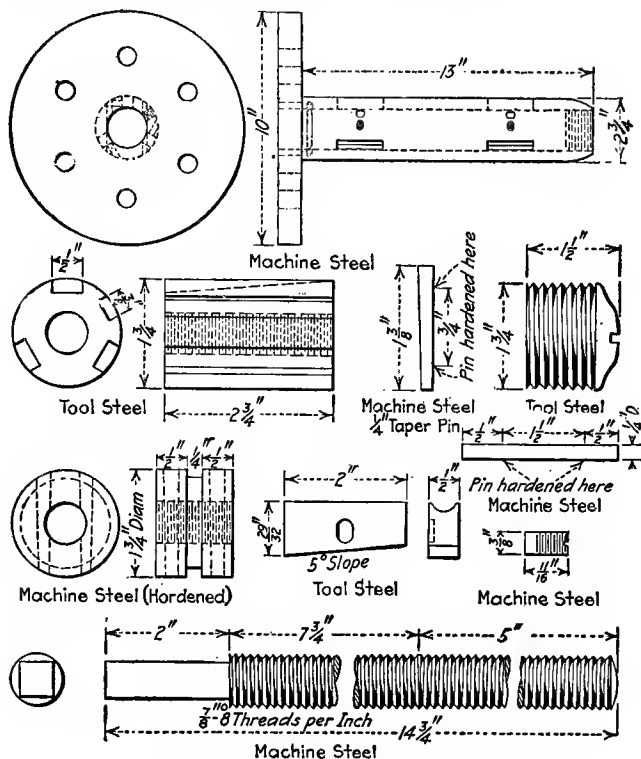
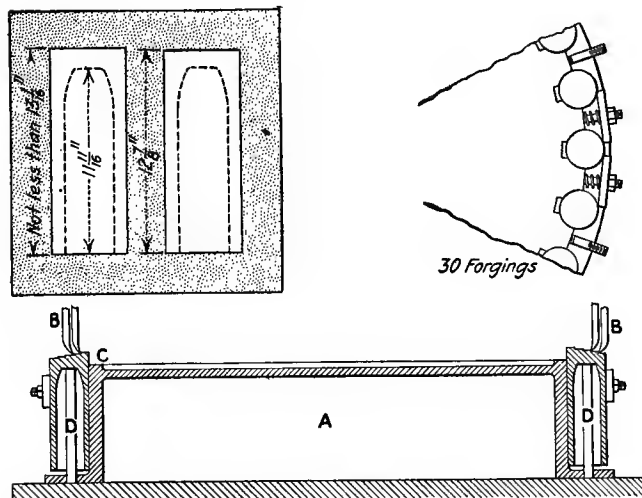


FIG. 7. DETAILS OF EXPANSION ARBOR

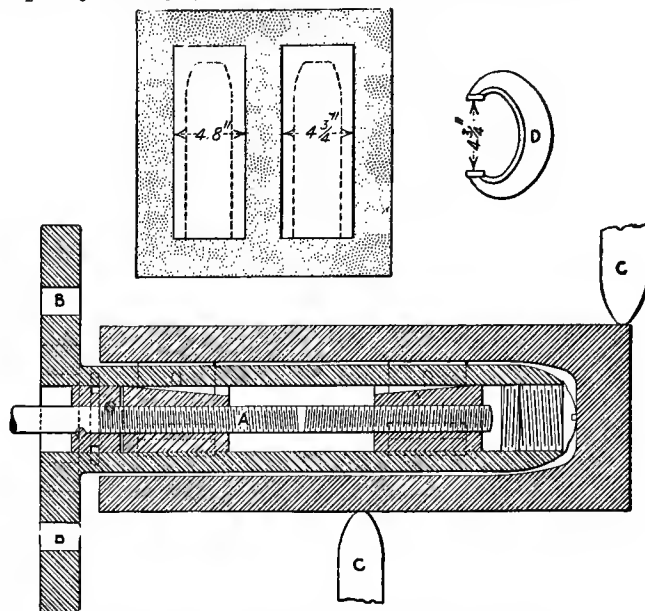


OPERATION 2: FACE ENDS OF FORGINGS

Machine Used—Bertram boring mill with 2 tools, B, in each head.
Special Fixtures and Tools—Circular chucking fixture A to hold 30 forgings. Special tool-holders to hold two tools, one behind the other, so spaced that the one is taking a chip while the other is in the space between forgings.
Gages—Height blocks to set tools from face C.
Production—One man and helper (for loading and unloading only), 30 per hr.
Reference—See Figs. 4 and 5

starts at the base end. The feed is approximately $\frac{1}{8}$ in. and the speed, all the tool will stand. As the forged hole is not concentric, the depth of cut is not uniform. In this operation the forging is reduced to $4\frac{3}{4}$ in. diameter. The output is from 8 to 9 per hour for each lathe.

A study of these operations, the tools used and the production secured will give a basis for estimating the capacity of any plant contemplating this work.



OPERATION 3: ROUGH TURN OUTSIDE

Machines used—Engine lathes, 24 to 36 in swing.
Special Fixtures and Tools—Expanding mandrel A driven by bolts in holes B, which hold it to lathe face plate. Tools C located to each cut half the length of work.
Gages—Snap-gage D.
Production—From one machine and one operator, 8 to 9 per hour.
Reference—See Figs. 6 and 7

Army Officers in Private Plants

While the recent decision of Secretary of War Garrison to allow army officers to resign for the purpose of building new plants for the manufacture of ammunition is a trifle unusual it should meet with general approval. For it should be remembered that they are always available should the Government require their services in its own plants and that there would be no hesitation in responding to the call.

This is in line with the sane policy of preparedness generally advocated, not by storing up hundreds of tons of war material that we hope never to use, but by preparing for its manufacture in case of necessity, in the shortest possible time. Another advantage will lie in the experience that will be secured by the officers who take the places of those going with private plants.

The question of remuneration, even though it be true that they will receive from four to five times their salary in the army, is not of great importance at this time. It would be perfectly logical of course, on account of all their education and training being at government expense, for their services to be loaned and the excess over army pay turned into the United States Treasury. But no one will begrudge them the extra remuneration if they bear in mind that the Government has first claim on them in any emergency.

By making everyone engaged in the manufacture of arms, ammunition and other war supplies fully realize that they are just as much a part of the army of defense as the enlisted men at the front, there will be no question of strikes, bonus or profits to delay production. Such an attitude, coupled with experience and facilities, is most effective preparation.

Manufacturing British 4.5 High-Explosive Shells--II*

BY E. A. SUVERKROP

SYNOPSIS—If it were possible to select one of a number of necessary operations on a piece of work and say, "This is the most important operation," one would be justified in choosing the fourth operation on the 4.5 high-explosive shell as being in that category. At a single chucking the work is subjected to 10 suboperations to prepare its exterior for another important operation, that of nosing.

At the time of writing six Warner & Swasey hollow hexagon lathes are occupied on the fourth operation, with a combined hourly output of 18 shells, which will probably be increased as the men become more familiar with the work.

One of these lathes is shown in Fig. 8, the photograph for which was taken from an elevation so as to show all the tools, with the exception of the roller turner.

The work *A*, as in the previous operation, is chucked on an expanding mandrel *B*. But in this set-up the flange of the expanding mandrel is bolted to the waving cam *C*, secured to the faceplate. Three tools are mounted in the turret tool-post on the cross-slide and five tools and a cup center are secured to the six faces of the hexagonal turret.

Operation sheet 4 gives by number the order in which the tools are presented to the work.

With the exception of the formed tool, marked 7 in the operation sheet, the tools in the cross-slide turret are simple ones forged from high-speed steel and ground to shape on an ordinary tool grinder.

All of the tools in the hexagonal turret with the exception of the Warner & Swasey roller turner were designed and built in the shop.

FACING THE BASE

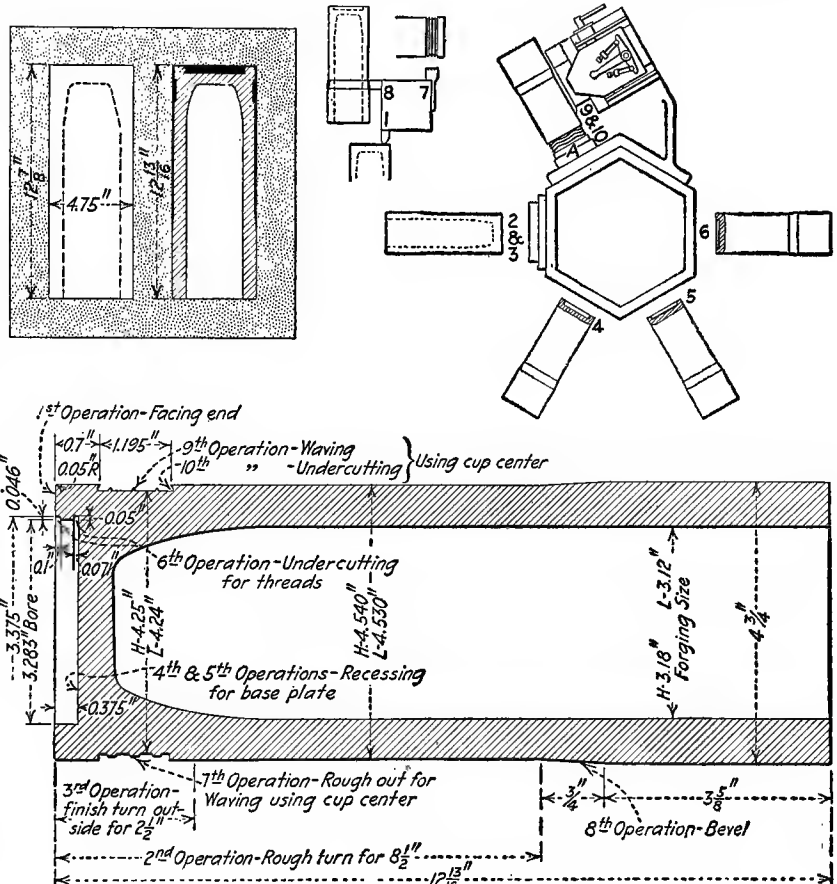
The operator faces the base end of the shell with the tool for suboperation 1. The cross-slide is then run toward the waving cam, out of the way of the next operation. The roller turner (shown in Fig. 9) for suboperations 2 and 3 is brought to working position and the shell is rough-turned for about 81½ in. (suboperation 2).

The turret is returned and the tool set in to finish to turning size. The shell is then turned to finished size (suboperation 3) for about 2½ in. The turret is indexed and the flat tool *D*, Figs. 8 and 10, roughs the recess for the base plate (suboperation 4). This tool is provided with three rollers *A*, Figs. 10 and 11, to support the base

of the shell during the recessing operation. These rollers are mounted on eccentric studs so that they can be adjusted should the work vary in size.

The finish recessing tool for suboperation 5 is a simple tool of square high-speed steel shown at *E* in Fig. 8 and likewise in both Fig. 12 and in the detail Fig. 13. A square hole is provided in the holder at *A*, Fig. 12. This holds a tool for rounding the bottom edge of the shell at the same time the finish recessing is done. As the radius of the round on the base edge is only 0.05 in., it has been found that the rounding can be just as quickly and satisfactorily done with a file. When in use the radius tool is mounted in the stationary steadying ring. The recess-finishing tool is mounted in a hand-operated cross-slide.

The sixth suboperation is performed with a hand-operated eccentric undercutting tool shown at F, Fig. 8, and in Figs. 14 and 15. The circular cutter, with the



OPERATION 4. FINISHING OUTSIDE OF FORGING READY FOR BORING AND NOSING

two cutting edges shown at *A*, Fig. 14, is operated by the lever *B*.

The seventh suboperation is performed with the formed tool in the cross-slide turret tool post shown at G, Fig. 8, and in the detail, Fig. 16.

The roughing-out tools to prepare the work for waving are manufactured from high-speed steel in 12-in. lengths and cut to suitable lengths for the tool holders.

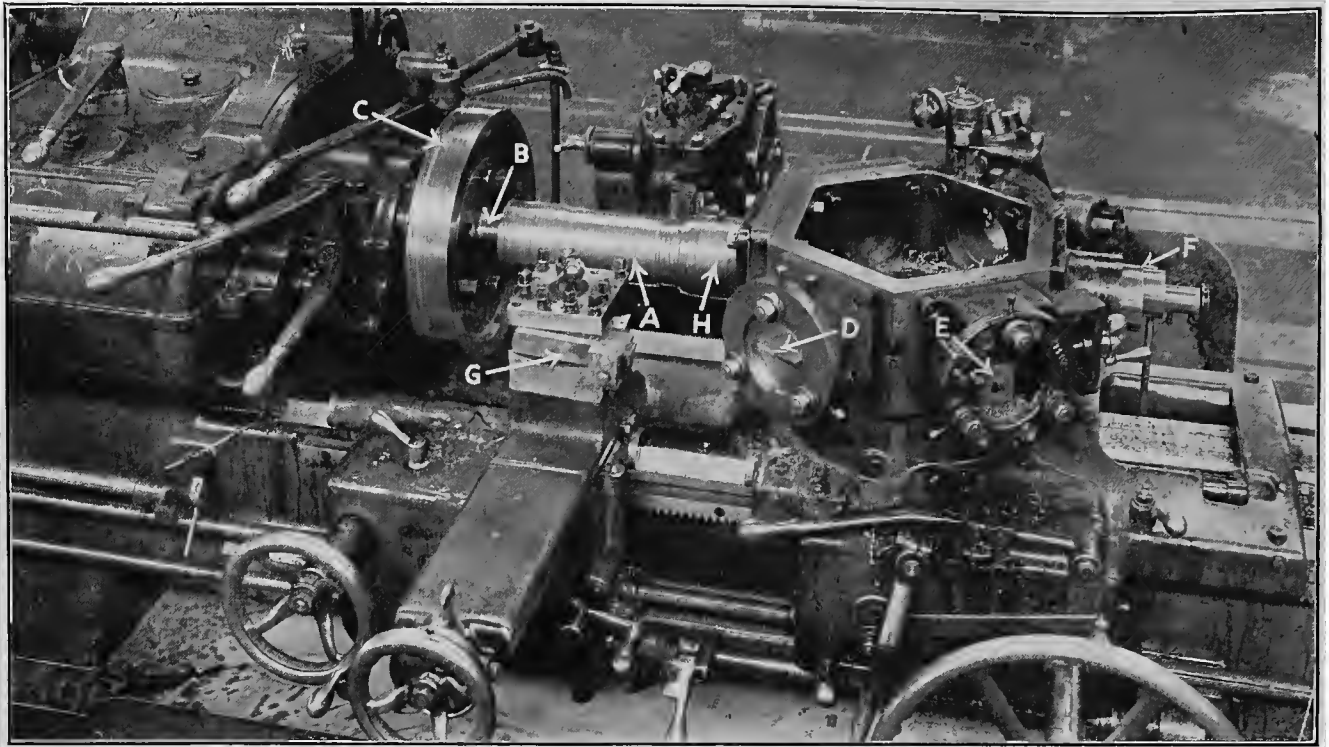


FIG. 8. WARNER & SWASEY TURRET ARRANGED FOR FOURTH OPERATION

In Fig. 17 are shown in detail the milling cutter for making the roughing tools and the tool for making the cutter.

The eighth suboperation is performed with a forged-steel tool held in the turret tool post in the cross-slide. It is $\frac{3}{4}$ in. wide, ground at an angle so that the advance edge is flush with the $4\frac{3}{4}$ -in. diameter of the work and the rear edge flush with the diameter to which the work was roughed in the second suboperation.

For the ninth and tenth suboperations—waving and undercutting the wave groove respectively—the cup center

H, Figs. 8, 18 and 20, is used to support the work. The cup center is shown in detail in Fig. 21.

Waving and undercutting are done by a combination fixture of exceptionally clever design.

DESCRIPTION OF WAVING FIXTURE

The supporting bracket (Fig. 22) of the fixture is a single casting fitted and bolted securely to two of the faces of the hexagonal turret.

The cup center *H* is bolted to one of the wings of the supporting bracket, and thus forms practically a part of

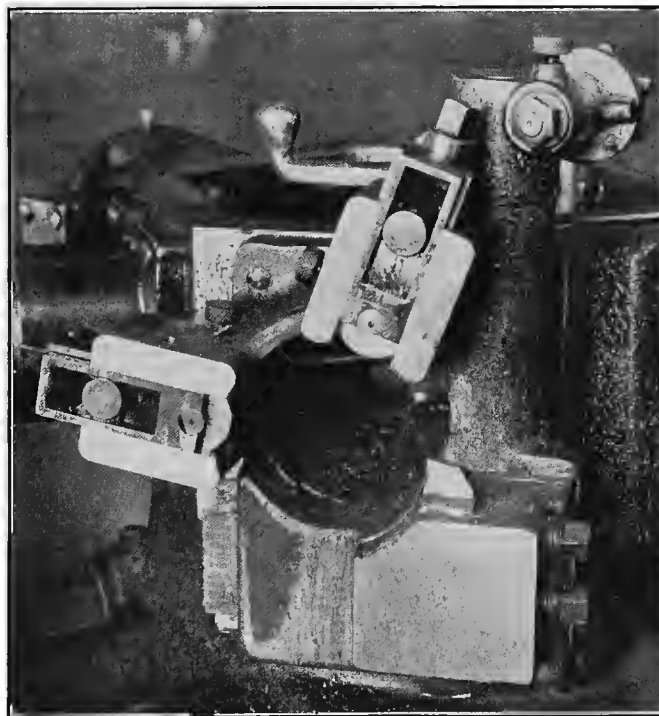


FIG. 9. WARNER & SWASEY ROLLER TURNER



FIG. 10. RECESS ROUGHING TOOL

the fixture itself. The fixture was designed for use on another machine while waiting for delivery of the Warner & Swasey lathes, and no assembly drawing has been made for it as applied to these lathes. However, the illustrations (Figs. 18, 19 and 20) will suffice to make it understood. Similar reference letters will be used in these three illustrations in order to avoid confusion.

The bracket *A*, shown in detail in Fig. 22, is bolted to two faces of the turret. On it is a machined slide for

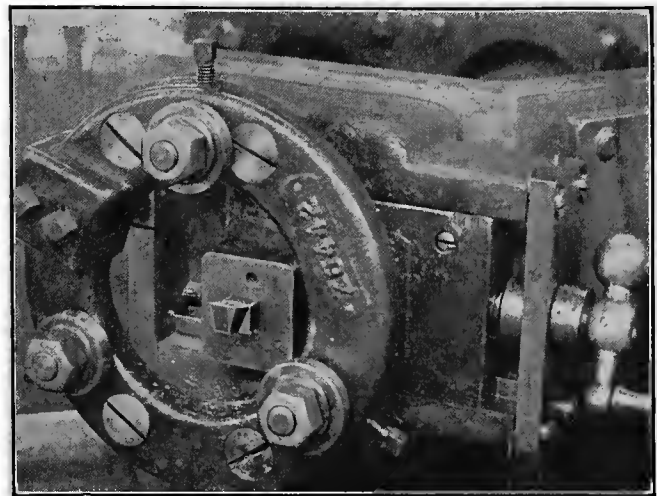


FIG. 12. FINISH RECESSING TOOL

the member *B*, which is operated toward or from the lathe center line by the screw *C*. This is in turn actuated by a socket crank in the hands of the operator. The member *B* is bored lengthwise of the lathe, to receive the plunger *D*.

The plunger *D* is splined to prevent turning and has a square hole in it for the reception of the shank of the

waving tool holder *E*. The tool holder *E* passes through an elongated slot in the member *B*, of sufficient width to permit of the necessary movement lengthwise of the lathe for producing the wave. An elongated hole is also provided at the top for similar traverse of the setscrew *F*, which is tapped into the plunger *D* and binds the tool-holder *E* therein. At the end nearest the lathe head and waving cam, the plunger *D* is bored to receive the shank of the roller holder *G*. This shank is threaded and provided with a nut for endwise adjustment, and is kept from turning in *D* by a key and keyway. The other end of *D*

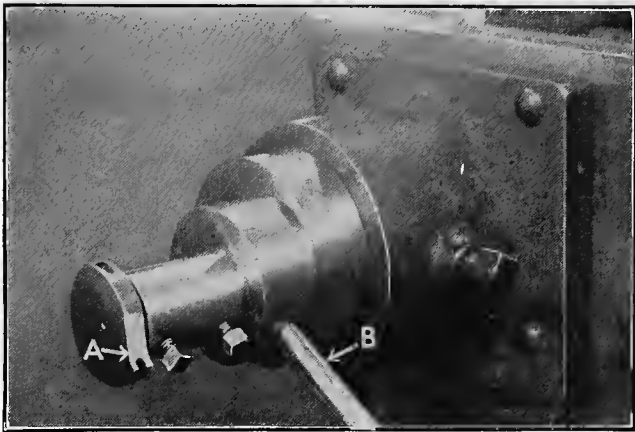


FIG. 14. UNDERCUTTING TOOL

is backed up by a heavy double helical spring to keep the roller against the cam ring while the fixture is in use.

THE UNDERCUTTING MEMBER

Hinged to the member *B* is the undercutting attachment *I*, which in Fig. 18 is shown thrown up out of the

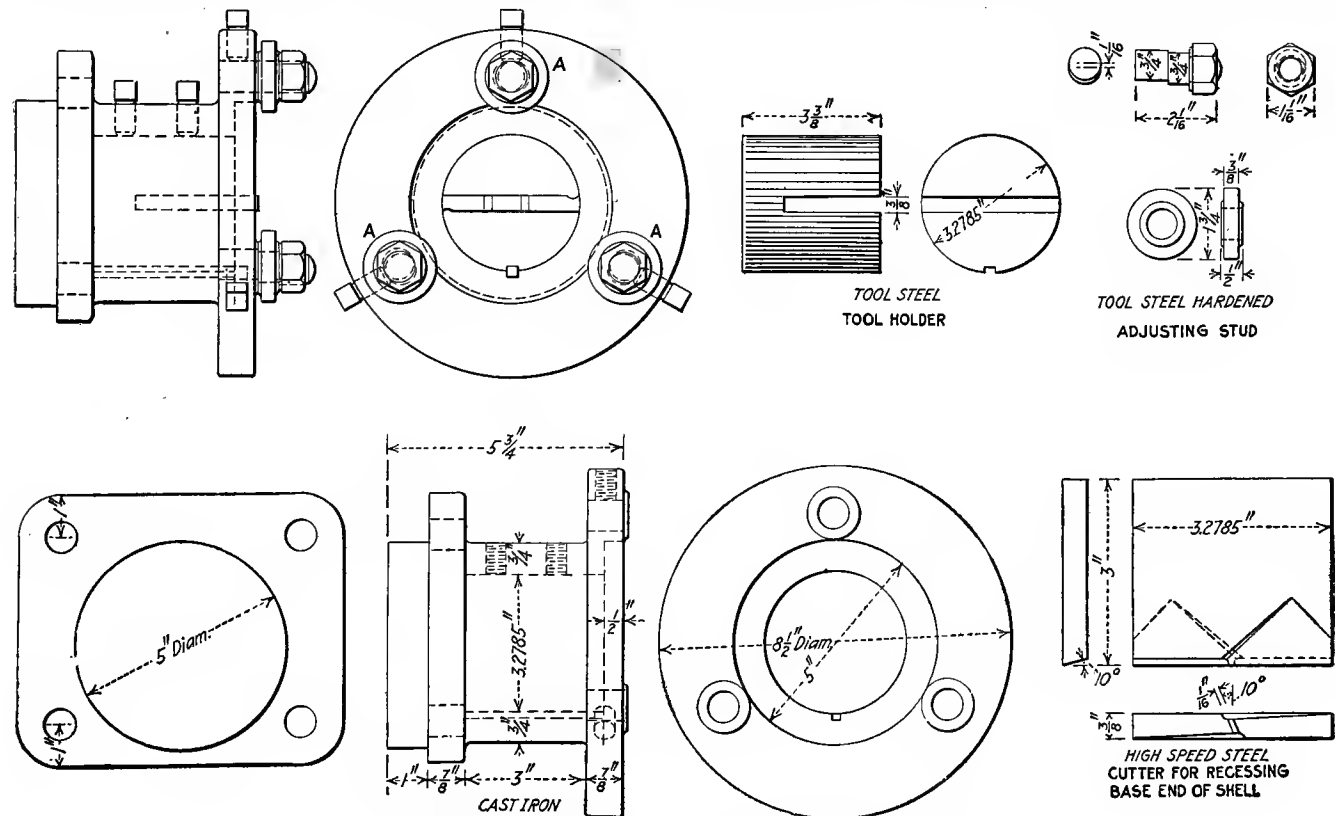


FIG. 11. ROUGH RECESSING TOOL AND HOLDER

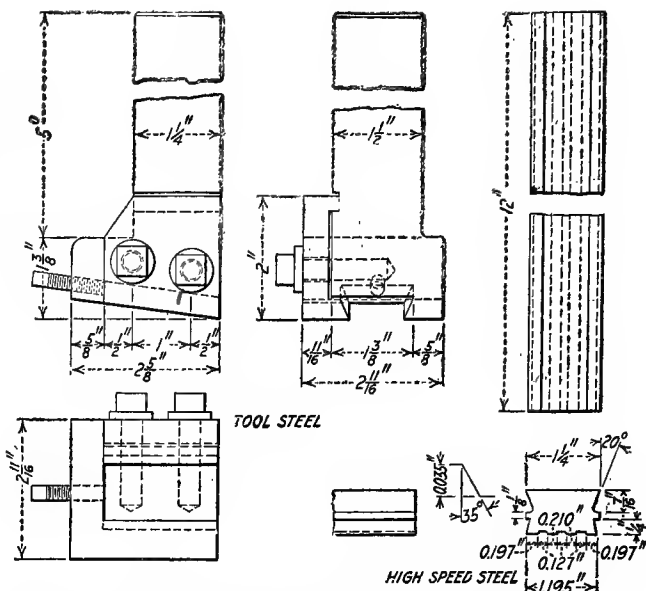


FIG. 16. TOOL HOLDER AND TOOL STOCK FOR ROUGHING
OUT FOR WAVING



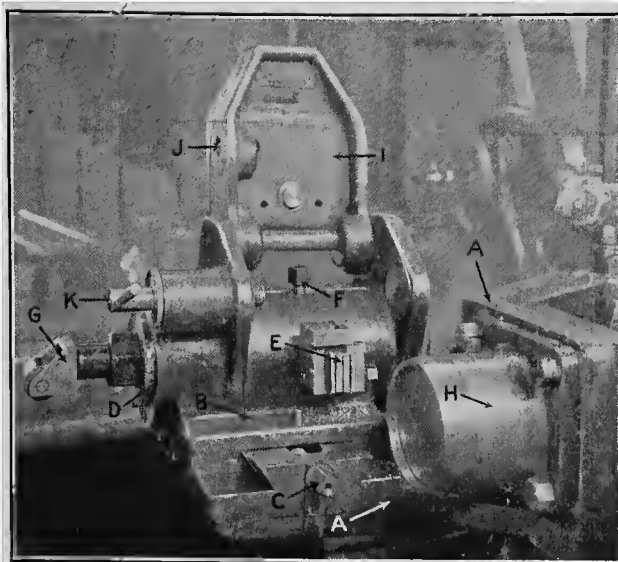


FIG. 18. WAVING ATTACHMENT WITH UNDERCUTTING MEMBER RAISED

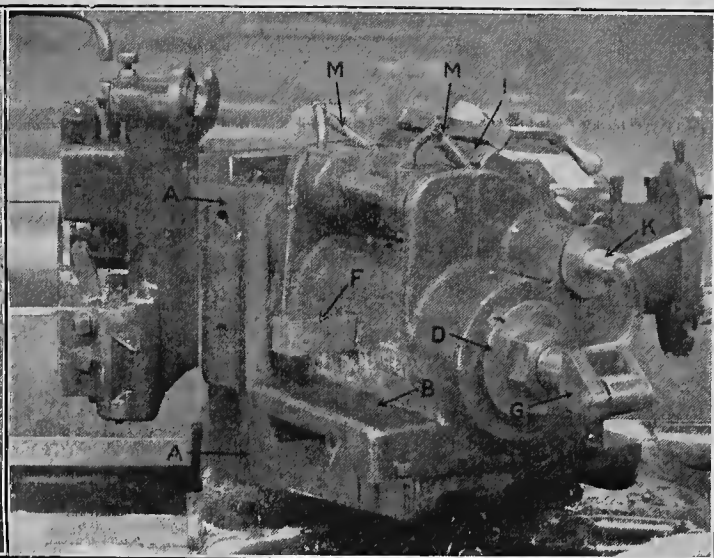


FIG. 19. REAR VIEW OF WAVING AND UNDERCUTTING ATTACHMENT

way and in Figs. 19 and 20 in working position. The member *I* is provided with a bushing *J*. When this is in line with and locked by the pin *K* the undercutting attachment is in working position. While the waving attachment is in use the lower edge of the member *I* rests on the pin *K* in its position as shown in Fig. 18. In this position the undercutting part of the fixture does not interfere with the operation of the waving part.

Referring to Fig. 20, two slots machined in the member *I* meet at the opening *L*. In these slots two tool-holders are fitted so that they will slide readily. A tension spring *M* holds them back in their respective slots. Each tool-holder is provided with a pin *N*.

When the lever *O* is swung one way or the other the wings *P* striking one or other of the pins *N* force an undercutting tool *Q* down to its work, as shown in Fig. 20.

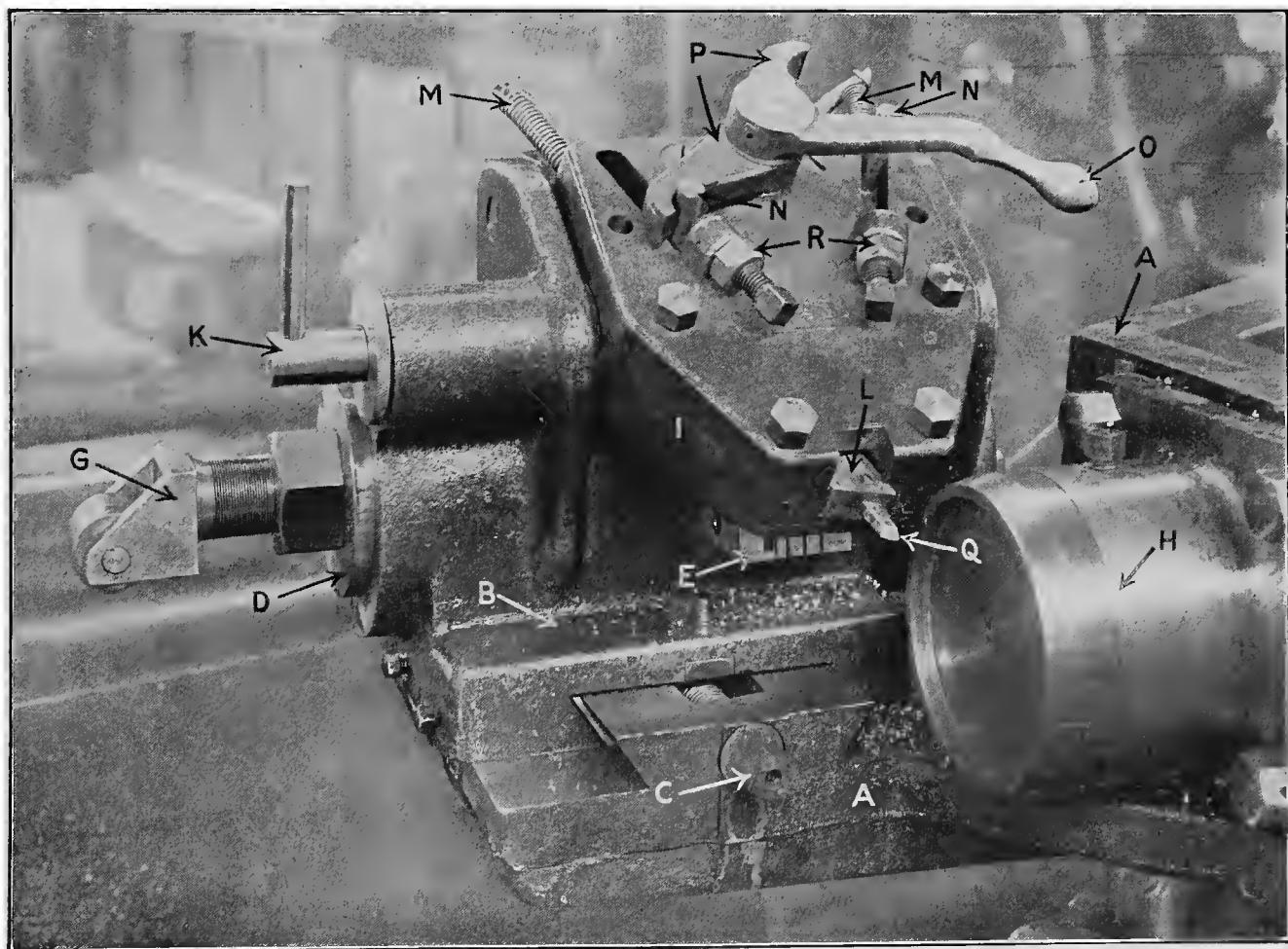
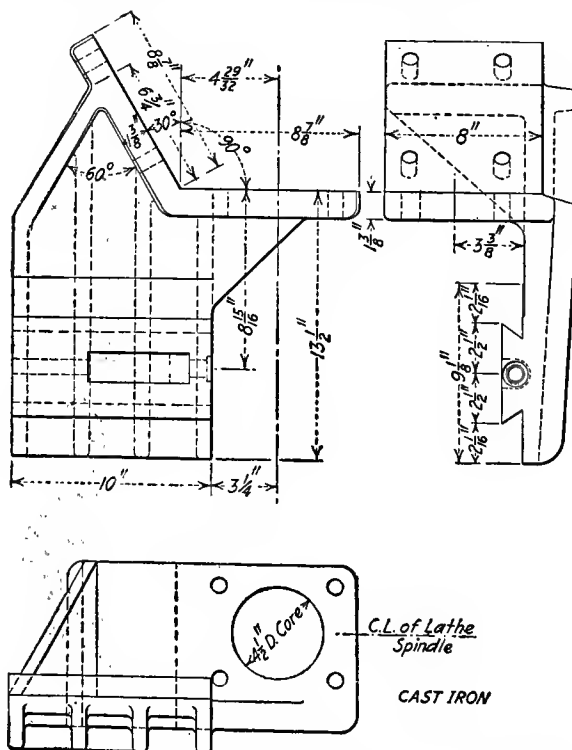
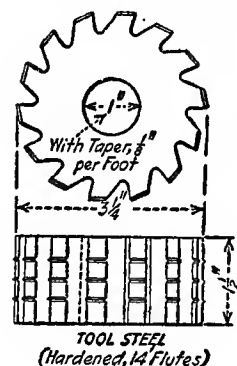
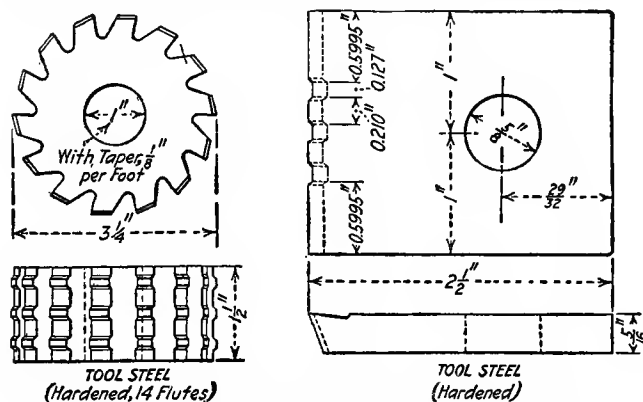


FIG. 20. ENLARGED VIEW OF CUP CENTER AND WAVING AND UNDERCUTTING ATTACHMENT

The formed wave tool E is then fed to correct depth. The tool is moved from side to side of the groove, alternately by the wave cam and the heavy helical spring, which keeps the roller in contact with the wave cam. During

Returning to the waving, which is the ninth suboperation. The roller holder *G* (Fig. 18) is slipped into its seat in *D*, and the turret is run forward so that the cup center *H* supports the end of the work, as shown in Fig. 8. This brings the roller against the face of the wave cam *C* (Fig. 8). The lathe spindle is stopped in such position that the roller is in one of the hollows of the wave cam. When the cup center brings up against the base of the shell the carriage is locked to the bed and the lathe started. With a socket crank on the screw *C* (Fig. 18) the member *B* is fed toward the already roughed wave groove.



alternately fed to depth in their respective cuts. The undercutting tools complete the fourth operation..

As previously stated, there is no assembly drawing of the waving and undercutting attachment. However, Fig. 23 gives a number of details which have been found to be

time to build and even the smaller and apparently more effective submarine cannot be built in a few weeks. Aëroplanes are the cheapest to build, and can be constructed very quickly, and no nation could hope to wage successful warfare, even in defense, without a large fleet of

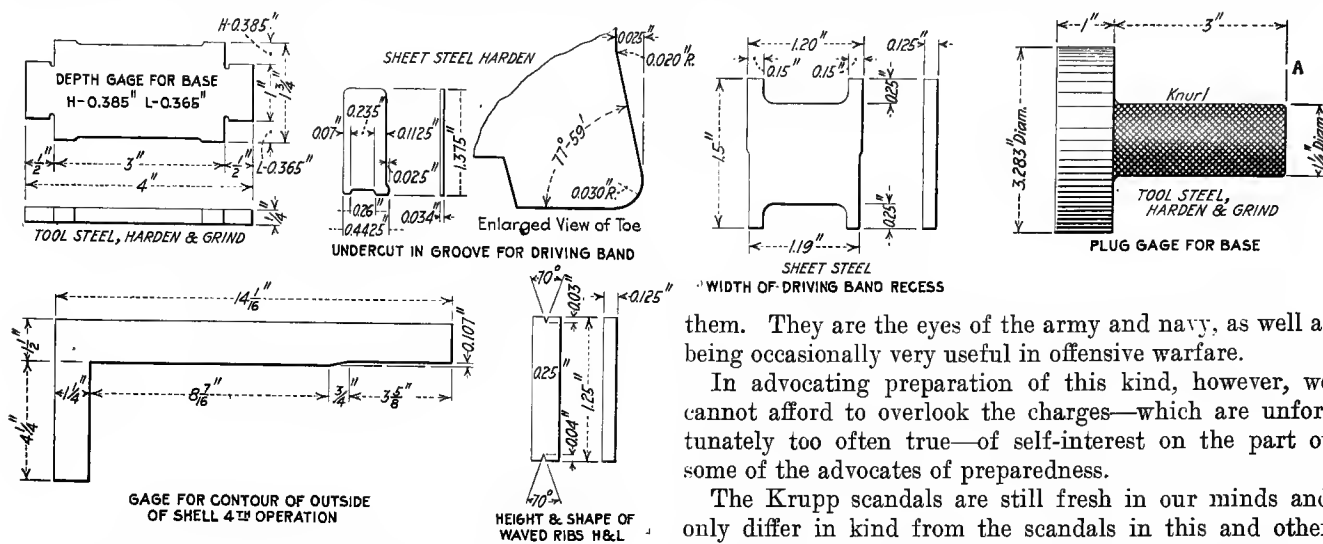


FIG. 25A. OTHER GAGES FOR FOURTH OPERATION

satisfactory under working conditions, and with these as a help the design of the body of the fixture should be easy. In Fig. 24 are shown the waving tool, the milling cutter for machining it and the tool used for turning the milling cutter.

Owing to the large number of gages necessary for the fourth operation it is impossible to show these properly in the small space available on an operation sheet. For that reason they are grouped by themselves in Fig. 25 and in Fig. 25A.

Economical and Patriotic Methods of Preparedness

The question of preparedness has many angles. To the jingoist it means the immediate enlistment of a million men, the building of many battleships, and all the other paraphernalia of war. To the saner citizen it means a careful study of our defensive needs and of the methods of supplying them with the least possible delay and at the least cost.

One of the great lessons of the present war is the vital necessity for organizing the shops and industries which can make war material in case of need, as has recently been inaugurated by the Government. This is devoid of all sensationalism and could in no way be said to provoke hostilities. Nor is there even need of secrecy in regard to it. In fact it can be clearly shown that secrecy has been responsible for many of the blunders of the present war.

If it were known that one shop had an equipment that could turn out 4,000 shells a day inside of 30 days, that the shop in the next block could make the timing heads, and still another draw up the brass cases, we would have a potential preparedness which could be counted on as surely as the men to man the guns to fire the shells in case of need.

There are, however, certain implements of war which must be made ready in advance. Battleships take a long

them. They are the eyes of the army and navy, as well as being occasionally very useful in offensive warfare.

In advocating preparation of this kind, however, we cannot afford to overlook the charges—which are unfortunately too often true—of self-interest on the part of some of the advocates of preparedness.

The Krupp scandals are still fresh in our minds and only differ in kind from the scandals in this and other countries in all ages and all wars. These scandals invariably come to mind when we hear those whose dividends come from armor plate and munitions advocating a larger army and navy. And while this may be unwarranted at times, the suspicions are not easily overcome.

The only way in which such advocates can disarm all suspicion as to their sincerity is to have a clause placed in any appropriation to the effect that all material supplied the United States Government for war purposes shall be at cost, plus a very nominal profit, of, say, 5 per cent. In time of war all supplies should be absolutely at cost, which is to include all depreciation and usual charges, but no profit.

This would effectually silence all carping criticism. And real patriotism demands no profit for its ability to aid in the national defense.

Nor should it be forgotten that the destruction of such plants as those which can make armor plates and battleships would be a far greater loss than the usual dividend on the material sold. If, then, such preparedness is necessary for the country's safety, it is equally necessary for manufacturing plants.

Only reliable products

can be

advertised in the

American Machinist

Manufacturing British 4.5 High-Explosive Shells--III*

By E. A. SUVERKROP

SYNOPSIS—In the fifth operation the inside of the shell is finished to size, the open end of the shell faced to bring the work to correct length, the base brought to the proper thickness and the mouth tapered for the next operation. The sixth operation shapes the nose, and the work assumes the familiar form suggested by the word "shell."

Boring and finishing the interior, which is the fifth operation on the 4.5 high-explosive shell, is almost, if not quite, as important as the preceding one, for the result of these two is to bring the work within reasonable range of the established weight limits.

This operation is performed on turret lathes of various makes, on a double-spindle turret lathe, which has been evolved from an old double-spindle machine built by Bertram for boring rock-drill cylinders, and also on a gang of vertical boring mills.

In Fig. 26 is shown a Steinle turret lathe set-up for the fifth operation and in Fig. 27 the Bertram rock-drill cylinder boring machine set-up for the same operation.

The work *A* is held in the collet chuck *B*, Fig. 26; shown also in detail in Fig. 28.

The first tool presented to the work is the four-fluted chucking reamer *C*, Fig. 26; shown also in detail in Fig. 29. This tool takes a cut the full length of the straight part of the bore, and is a great producer. At first these

The second bar *D*, Fig. 26, carries two tools—the rough boring and seat-facing flat cutter *E* and the mouth-reaming flat cutter *F*, both of which are shown in Fig. 29. If the lengths of the cutting edges of these two tools

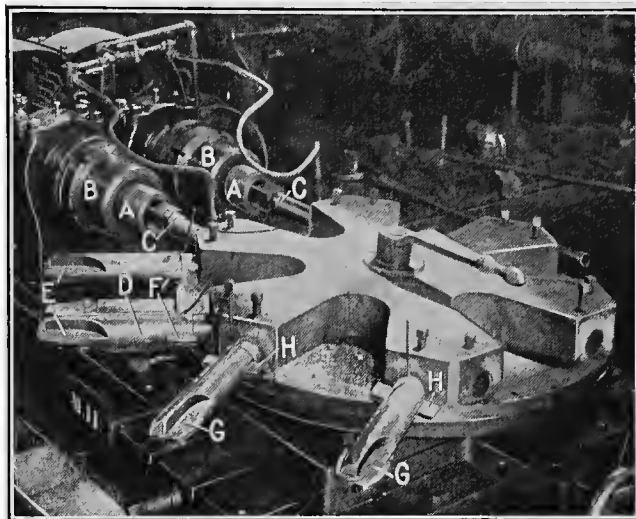


FIG. 27. BORING SHELLS ON DOUBLE-SPINDLE BERTRAM MACHINE

be measured and added together it will be apparent that considerable power is necessary to pull the cut, and that the gripping power of the chuck must be great to prevent slipping. In order to avoid delay, the collets for the

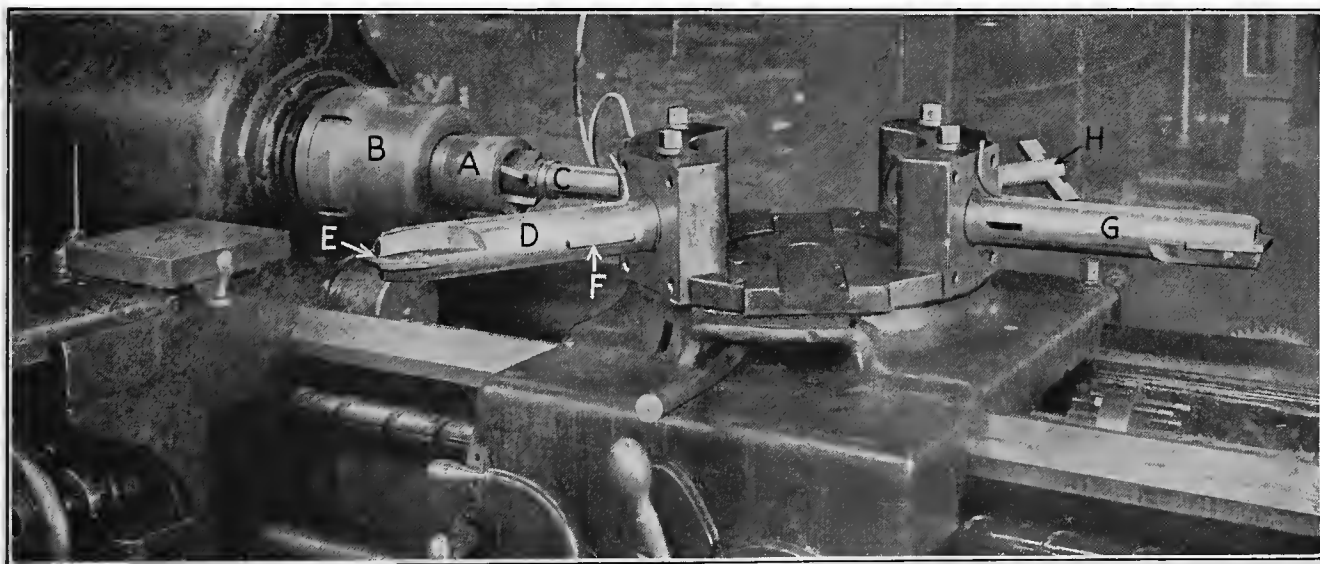


FIG. 26. STEINLE TURRET LATHE SET-UP FOR BORING SHELLS

reamers were made with right-hand spiral flutes, but it has been found in practice that a reamer with straight flutes works equally well. The lubricant—soda water—passes through a central hole in the reamer arbor. Squirting in ahead of the cut, it washes the chips back through the flutes, which are of ample size for their passage.

chucks were at first made of cast iron with cylindrical bore. They are now made of cast steel with lengthwise V-shaped grooves, and slipping of the work in the chuck has been entirely overcome.

The finish-boring and seat-facing flat cutter *G* is next presented to the work. This cutter is also shown in detail in Fig. 29. It finishes the hole to size and depth. The

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facing cutter *H* completes the fifth operation by facing the shell to length.

The tooling for the various machines for this operation is similar, but not the same. Changes have been made necessary by variations in the pulling power of the ma-

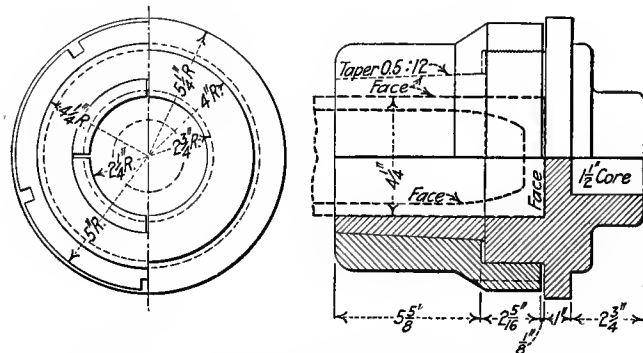


FIG. 28. SHELL CHUCK FOR USE ON LATHES

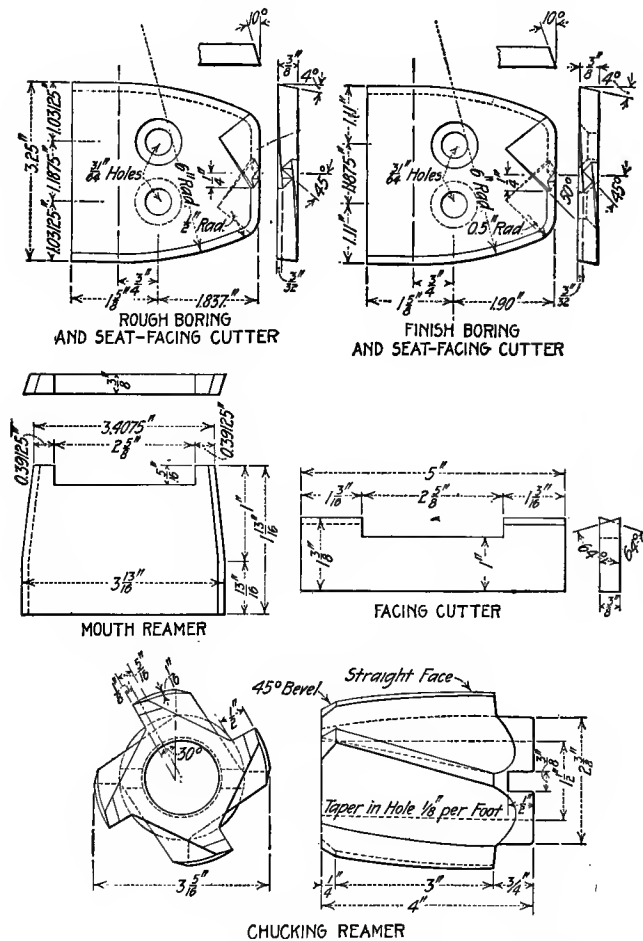


FIG. 29. CUTTERS USED IN FIFTH OPERATION

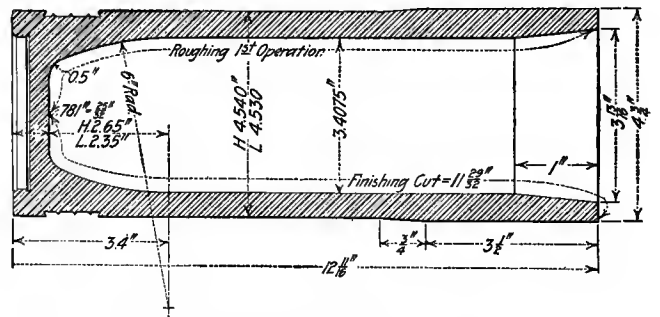
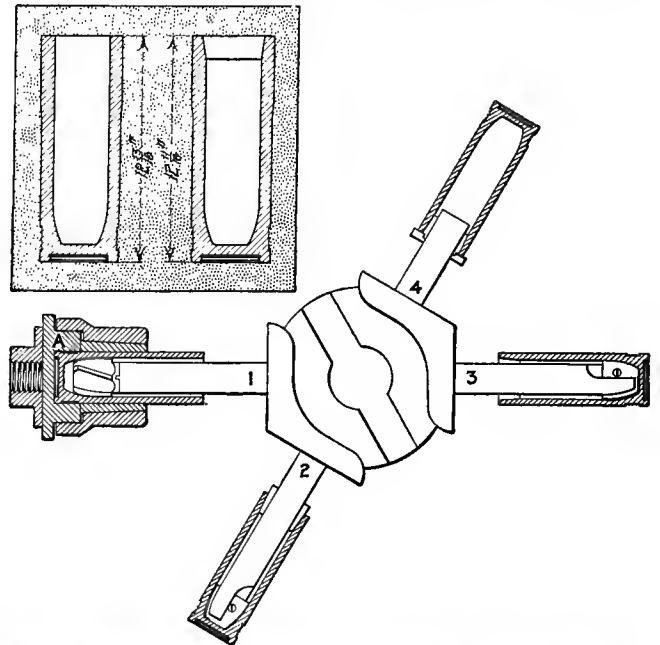
chines. It will be noted that four stations are used on the Steidle lathe and only three on the Bertram machine. The fourth tool in the Steidle set-up is mounted together with the third in the Bertram set-up. This was made possible because of the great power of the last-mentioned machine.

The output of the Steidle lathe is about 4 per hour and on the double-spindle lathe about 6 per hour.

Too great emphasis cannot be placed on the necessity of having powerful machines for this operation. The drives of all the machines with the exception of the

double-spindle turret have been a repeated source of annoyance and delay. Cast-iron gears have no place in a drive of which so much is required. All gears should be of alloy steel, heat-treated. They should have large teeth and wide faces.

The bars used for this operation are shown in Fig. 30. The method of fastening the flat cutters in the bars is excellent. Referring to section *AB*, Fig. 30, it will be noted that the end of the bar is slotted entirely through. The direction of the cutting forces tends to spread the



OPERATION 5. FINISH INSIDE OF SHELL AND FACE OPEN END

Machine Used—Steidle, Davis and other turret lathes and vertical boring mills.
Special Fixtures and Tools—Special collet chuck *A*. Special 4-flute chucking reamer and bar for suboperation 1. Special flat 2-lip rough-boring tool and 2-lip taper-reaming cutter and bar for suboperation 2. Special 2-lip finish boring tool and bar for suboperation 3. Special 2-lip facing cutter and bar for suboperation 4.
Gages—None, as tools are made to size and machine stops are used for depths.
Production—From single machine and one operator, 4 per hour; double machine and one operator, 8 per hour.
Note—Soap water lubrication through tubes in boring bars. Reference—See halftone Figs. 25, 26, 30 and line cuts Figs. 27, 28, 29.

members *C* and *D*, but the cutter *E* is secured with two flat head screws *F* and *G*, one in each member *C* and *D*, which bind these two together and prevent spreading.

SET-UP FOR BORING MILLS

Besides the turret lathes, a gang of small boring mills is also used on this same job. Owing to the difficulty of removing the chips, three handlings, from machine to machine, have been found more economical than completing the hole at one chucking.

Each boring mill is provided, as shown in Fig. 31, with a single tool, chucking reamer, roughing reamer or finishing reamer, as the case may be. The work is chucked in collet chucks similar to those used in the lathes, and the tool fed to depth. When the work is removed and passed to the next machine the chips are dumped out. If the three bars were used in the one machine the accumulation of chips would require removal between operations, and

tionally long guides and is eminently suitable for the nosing job. At *F* is a hydraulic nosing press, designed and built in the works, to take care of the nosing job in case of accident to the steam hammer. The tongs *G* are supported at the correct height by chains from the trolley on the overhead track *H*. This track is rigid, as the

OPERATION 6. NOSING

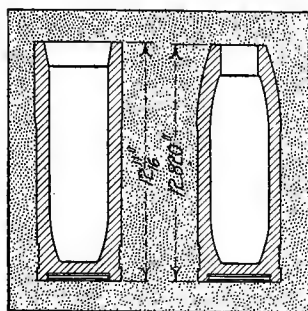
Machines Used—Steam hammer and special hydraulic forging press.

Special Fixtures and Tools—Two special oil-fired furnaces. Special tongs for handling the work. Overhead trolley support for tongs and work. Special top and bottom dies for steam hammer and hydraulic press. Workstand to facilitate handling. Annealing floor. Trucks and tracks to machining department.

Gages—None.

Production—Steam hammer and three men, 4 shells per minute. Press output not yet determined.

Note—Output is controlled by the speed of the furnaces.



References—See halftones Figs. 31, 32, 33 and 34 and line cuts Figs. 35 and 37.

with the work in vertical position much time would be lost. The tools used in the boring mill are of course similar to those used in the turret lathes.

The shells from the fifth operation are loaded on trucks and run out to the nosing department, which forms a part of the forge shop. Taken from the trucks, the shells are stacked at *D*, Fig. 32. The equipment for nosing is simple but complete. The entire outfit is shown in this illustration. At *A* is an oil-fired nosing furnace, of which there are at present two, built by the Strong, Carlisle & Hammond Co., Cleveland, Ohio. The waterjacketed front casting *B* accommodates seven shells. Seven shells from the fifth operation occupy the top of the stand *C*. The Bertram steam hammer *E* has excep-

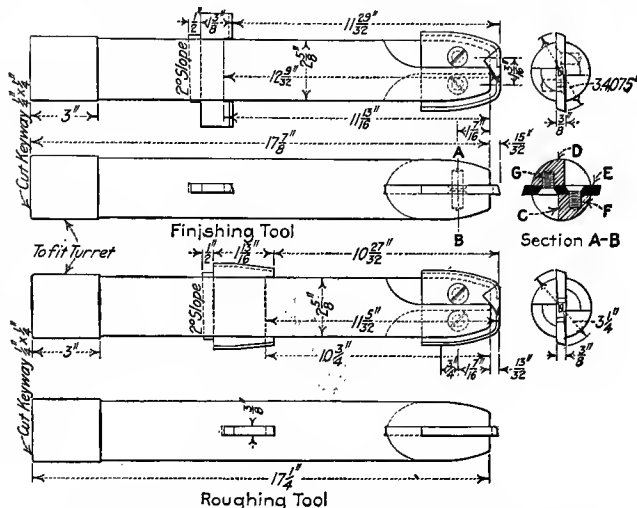


FIG. 30.—BORING BARS FOR ROUGH AND FINISH BORING, FACING AND REAMING FLARE

chain is flexible enough to permit the amount of movement necessary. The tongs *G* are for handling the cold shells from the stand *C* into the furnace *A* and removing the hot ones from it. The tongs *I* are for taking the hot shells from the tongs *G* and handling them into and out of the lower die on the steam-hammer block.

The nosing gang consists of two men and a hammer man. Seven shells are placed on the stand *C* by the man who handles the work to and from the hammer. The man

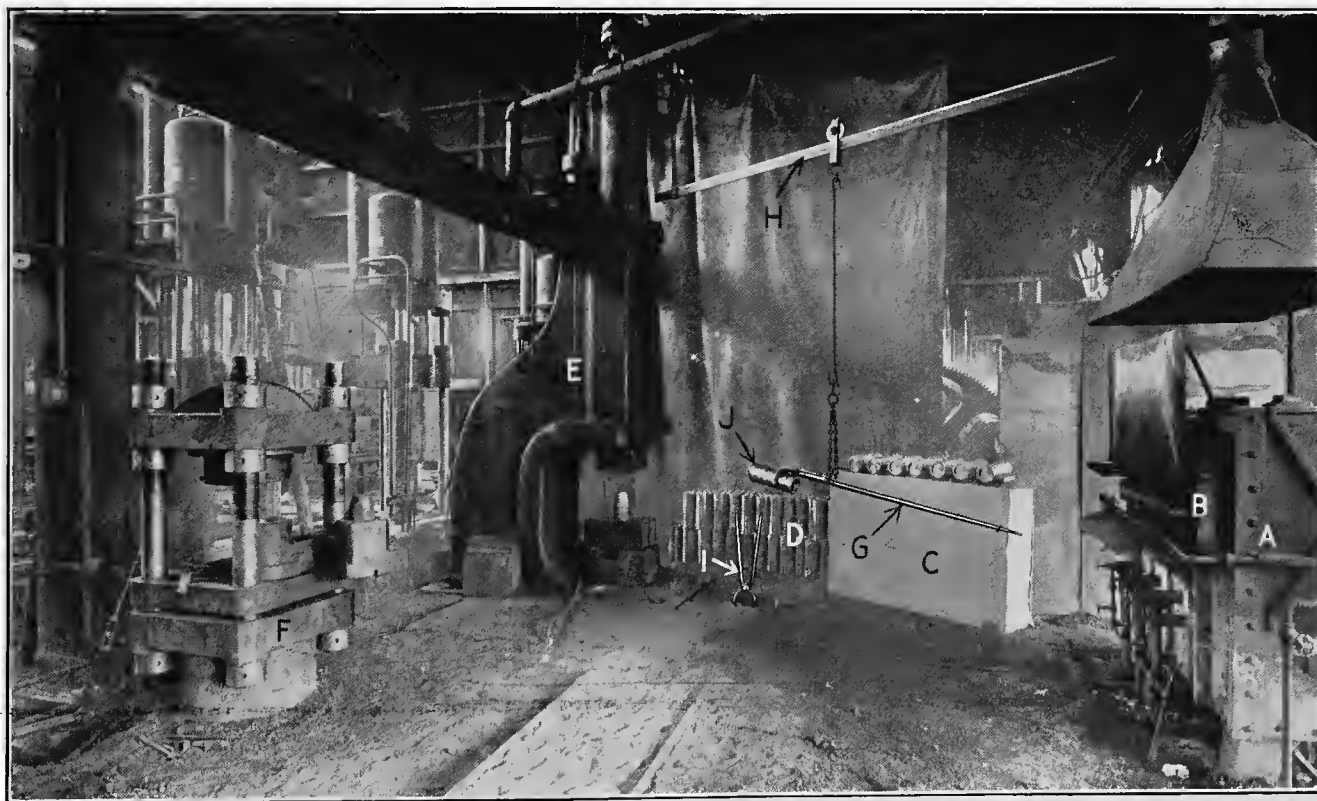


FIG. 32. COMPLETE EQUIPMENT OF NOSING DEPARTMENT

who handles the long tongs *G* places the shells in the furnace. While the first charge of shells is heating seven more shells are placed on top of the stand *C*.

The charging of the furnace is from left to right. When the first shell has attained the proper heat the first operator removes it with the tongs *G*, swings it around to the position shown at *J* in Fig. 32. The second

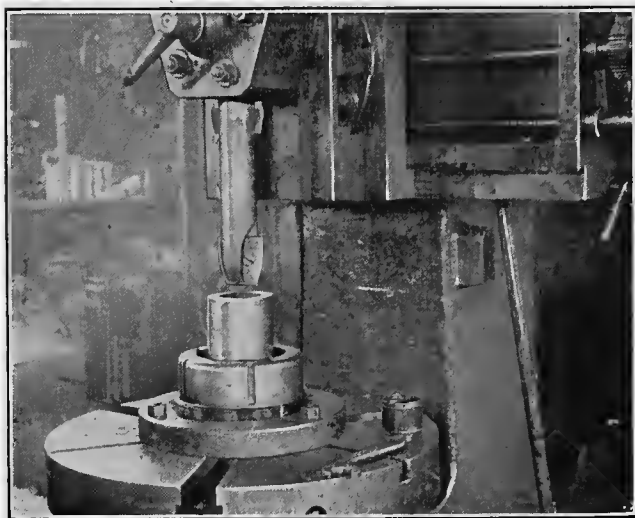


FIG. 31. BORING SHELLS ON VERTICAL MILL

operator takes it with the tongs *I* and places it nose end up in the bottom die block on the steam hammer.

From two to three strokes of the hammer are sufficient to form a perfect nose.

While the nose is being formed the first operator swings the tongs *G* back, picks up one of the shells from the stand *C* and inserts it in the vacant opening in the furnace. As soon as the nose is shaped the second operator lifts the work from the bottom die with the tongs *I* and

the furnace. After all the shells of a charge are nosed the hammerman places them nose down in about 2 in. of ashes on the annealing floor to cool slowly, the second

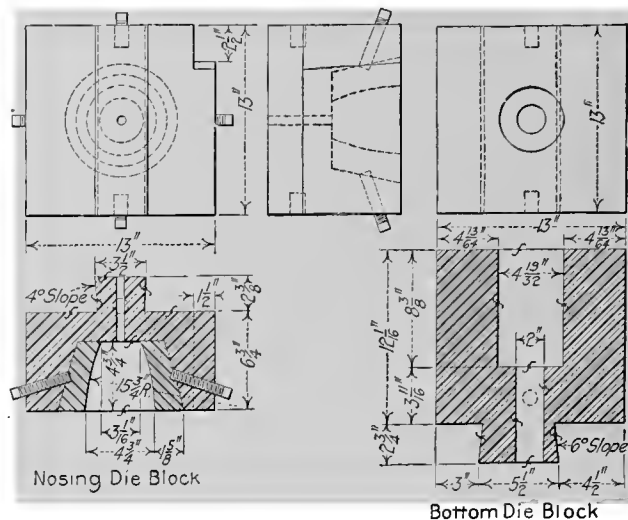


FIG. 35. NOSING DIE BLOCKS FOR STEAM HAMMER

operator refills the top of the stand *C*, and the operation is repeated with the shells in the second furnace.

Taken by the day, nosing takes about 15 sec. per shell, which is the heating capacity of the furnaces.

The furnace shown in Fig. 33 is one of two similar furnaces. It is 7 ft. 6 in. wide by 3 ft. 6 in. deep. It is built up of cast-iron plates and lined with firebricks. Three 1¼-in. low-pressure oil burners are used. The casting for the reception of the shells is waterjacketed, and a continuous circulation of water keeps their bodies cool while their noses are brought up to the required temperature.

No figures on oil consumption are at present obtainable. In all work of this sort, where the formation of scale is

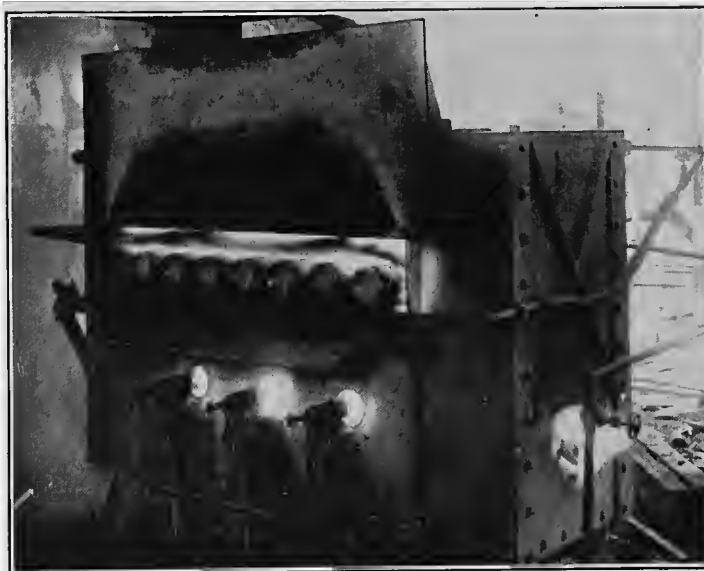


FIG. 33. NOSING FURNACE, HEATING CAPACITY 1 SHELL PER MINUTE

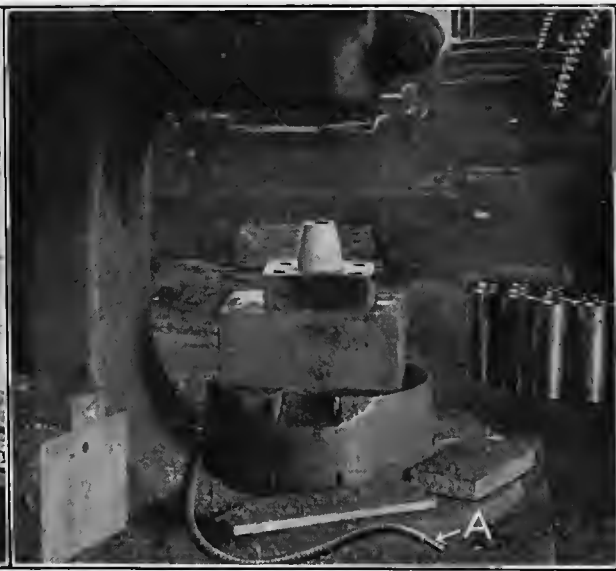


FIG. 34. THE NOSED SHELL IN THE BOTTOM DIE

lays it on the floor, out of the way. By this time the first operator has removed the second hot shell from the furnace, and the operation just described is repeated.

Nosing in this manner is a very rapid operation. It takes just 65 sec. to nose the seven shells and recharge

objectionable, the amount of oil used should be in excess of that necessary for perfect combustion, so as to produce a reducing flame in the furnace.

In Fig. 34 is shown a shell in the lower die after nosing. The upper and lower dies are so dimensioned that

when their two faces come together nosing is complete. The lower die has a 2-in. central hole clear through it, so that dirt and scale can be easily blown out by the air hose A. It will readily be seen that an accumulation of scale or dirt in the bottom die would result in nosed forgings of varying lengths. Details of the nosing dies of the steam hammer are shown in Fig. 35.

ANNEALING

At A in Fig. 36 are shown the seven shells of a furnace charge which have just been nosed and at B a small section of the annealing floor with the shells, their noses buried in ordinary ashes to a depth of 2 or 3 in., annealing for the next operation.

HYDRAULIC NOSING PRESS

The 100-ton hydraulic press shown in detail in Fig. 37 was designed and built in the works. To obviate loss of time as much as possible a two-station shell holder is provided. This pivots on one of the posts and is pro-



FIG. 36. NOSSED SHELLS COOLING OFF IN ASHES

vided with mechanism to lock it in either of its two operating positions. While one shell is being nosed in one station, the finished shell is being removed from and another heated blank placed in the other holder die. The hydraulic pressure available is 1500 lb. per sq.in. The speed of the hydraulic nosing press under working conditions is at this time not available. It is safe to say that it is very much slower than the steam hammer.



Indicating Gages for Shells

A contributor to the English edition of the *American Machinist* showed and described the use of indicating gages to determine the thicknesses of the base and walls of shells. The devices were originally made to gage the thicknesses of the head and walls of automobile-engine pistons. The similarity in the two uses is apparent.

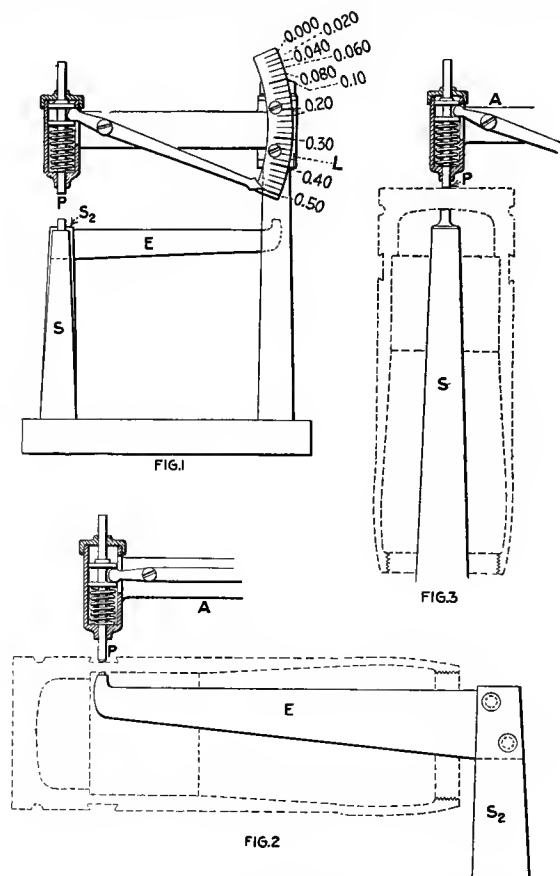
Turning to the illustrations, Fig. 1 shows the indicating gage complete, but without any work in place. But little explanation is needed. To measure the thickness of the base of a shell it is slipped over the post S , which has a hardened-steel wearing piece in the upper end; the arm A is swung around until the plunger P is directly over S and the plunger is pushed down against the resistance of the helical spring by means of a finger. This action causes the indicating arm to swing across the graduated

circular scale. The graduations are in 0.1 and 0.01 in. The ratio of the arms of the pointer is 5 to 1, thus gage measurements can be made to within 0.002 in.

The set-up for this shell-base gaging operation is shown in Fig. 3, the dotted outline being that of a shrapnel shell.

GAGING THICKNESS OF SHELL WALL

To obtain the thickness of the wall of a shell a second standard S_2 and its arm E are used. This post S_2 is located at the opposite corner of the base from the post S and the end of the arm E is similarly opposed to the standard carrying the graduated scale and support for the indicating arm. This indicating arm A can, however, be swung around until the plunger P is directly over the upturned point of the arm E , and when in this position



MEASURING DEVICE FOR SHELLS

it can be locked by nuts at the top of its supporting standard. To reach this position it moves through an arc of 90 deg.

The manner in which it is used in this position to gage the thickness of the wall of a shell is shown in Fig. 2, where the set-up is arranged to gage the thickness between the bottom of the driving band recess and the shell bore. It is obvious that this same method can be used for any other part of the wall of either a shrapnel or explosive shell.

Other applications of this device to the inspection of munitions will readily occur to anyone who is familiar with such work. The correspondent to whom we have referred believes that this type has a very large field of usefulness beyond that of gaging automobile-engine pistons for which it was first developed. Modifications in design can easily be made to increase the multiplication of the indicating-arm movement and thus permit of measuring to smaller limits.

Manufacturing British 4.5 High-Explosive Shells--IV*

By E. A. SUVERKROP

SYNOPSIS—In operations seven to eleven inclusive the shells are brought to what are practically finished sizes both inside and outside and undergo the first rigid general shop inspection for shape, size and weight. Having passed this successfully they are reasonably sure to go on through the subsequent operations without further trouble.

When the nosed shells have cooled off in the ashes on the annealing floor they are loaded on trucks and run back to the machine shop. The seventh operation consists of five suboperations—rough boring, finish boring, reaming the nose to tapping size, facing the shell to correct

In the tool post of the lathe is an ordinary Armstrong boring tool *C*. In the turret are three tools—the boring bar *D* with a single pointed tool, the reamer *E* and the facing cutter *F*.

The cross-feed screw has been removed from these lathes and a former carrier *G* bolted to the brackets *H*, which in turn are secured to the lathe bed. Fastened to the top of *G* is the former *I*, which is the shape to which the inside of the shell nose must be bored. A roller fitting the cam slot in the former is carried on the end of the link *J*, which is bolted to the cross-slide as shown. Thus as the carriage moves along the ways, the tool *C* in the toolpost is constrained to follow the form of the cam slot in *I*, and the boring tool reproduces this form in the

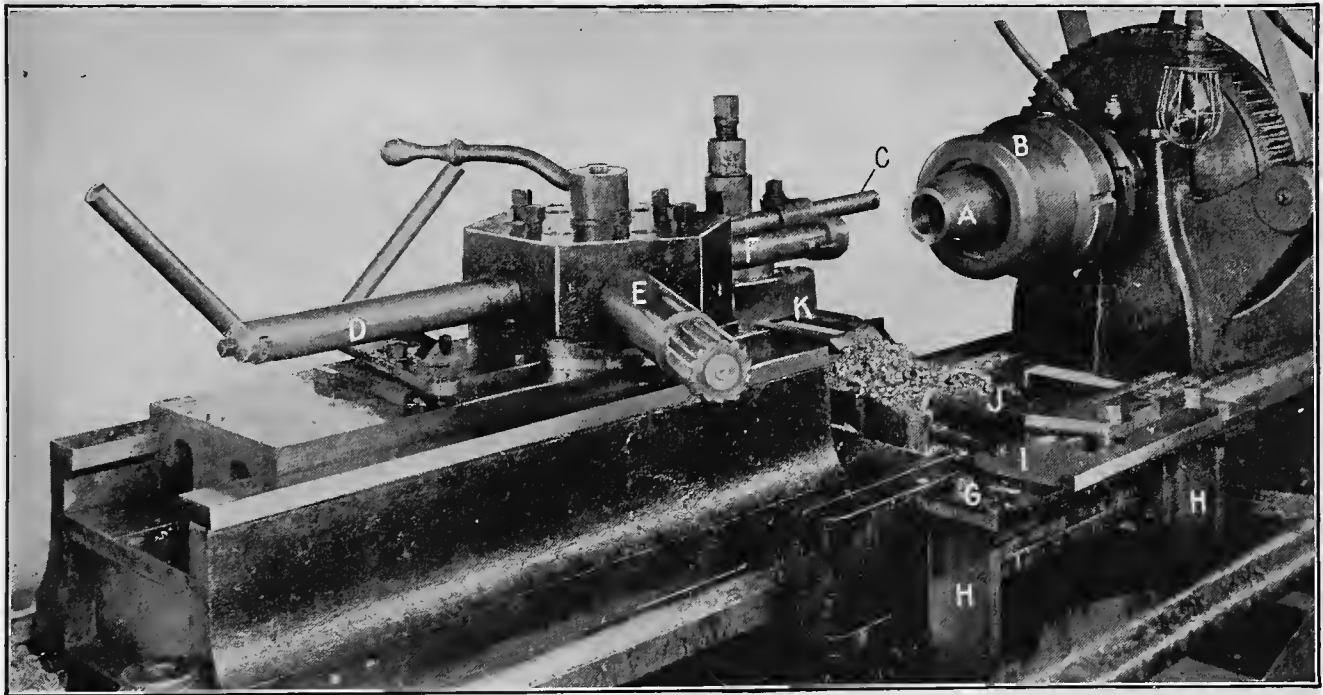


FIG. 38. BORING, FACING AND FORM-BORING NOSE END OF SHELL

length, and form-boring that part of the interior which was closed in beyond the parallel bore by the nosing operation.

A number of engine lathes have been fitted up for this operation. Collet chucks similar to those used in the fifth operation, and shown in Fig. 28, are mounted on their spindles. The tailstocks have been replaced by hand-operated hexagonal turrets designed and built in the works.

FORM-BORING LATHE

In Fig. 38 is shown one of these lathes set up for this job. At *A* is the work held in the collet chuck *B*. The work is pushed to its seat in the bottom of the chuck, which acts as a locating point from which the traverse of the facing tool is gaged. In this way uniform length of the finished shells is assured.

work. Above the regular cross-slide is the short cross-slide *K* to permit feeding the tool to and away from the work.

FORM-BORING AND FACING

The work *A* is secured in the chuck *B*. The turret is run back out of the way and the boring bar *C* in the toolpost run in and a roughing cut taken to true the hole. It is then run out and withdrawn by means of the cross-slide *K* to the position shown in the illustration.

The boring bar *D*, the tool in which is set to bore the work to reaming size, is then run in by hand. This is followed by the reamer *E*. In front of the facing cutter *F* is a hardened pilot which rotates freely on the end of the bar. It is a snug fit for the reamed hole in the nose of the work and supports the end of the bar. The facing cutter *F* is then advanced the correct distance, a mark on the turret slide indicating when correct depth

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is reached as a stop. The turret is again run back and the boring bar *C* in the tool post brought into action again. With the highest part of the edge of the tool in *C* in line with the edge of the faced hole in the work, the start of the curve of the cam should be $1\frac{1}{8}$ in. in advance of the center of the cam roll. Having set the boring bar so that this dimension is correct, a mark is made on the ways of

cam, which cannot be said of the single-edge cam, with the somewhat sharp follower held in contact by heavy weights.

In Fig. 40 are shown the details of the hand-operated turret. A number of these were built in the works to fit various sizes and makes of lathes. There was no attempt made to produce anything fancy. It is just a heavy stiff

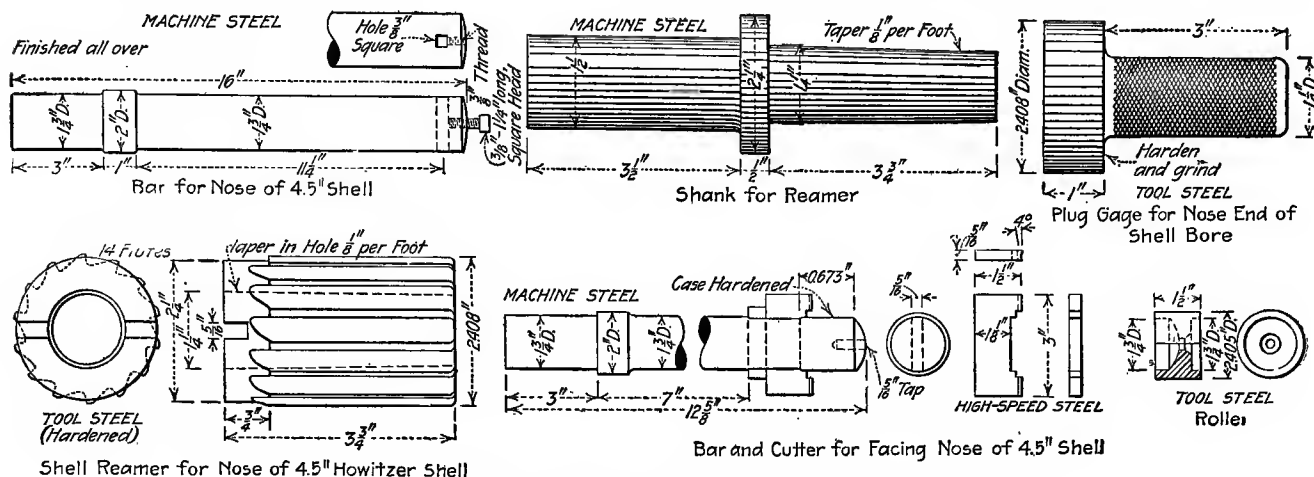
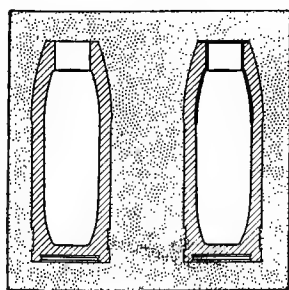


FIG. 41. TURRET TOOLS AND GAGES FOR SEVENTH OPERATION

the lathe $1\frac{1}{8}$ in. in advance of a mark on the carriage. Once set, this adjustment need not again be made, as the cutter can be removed and ground without disturbing the holder or bar. The carriage is then advanced to this mark (without the tool cutting), the tool fed to the cut by the upper cross-slide *K* and a cut taken. Two cuts are usually taken, the operator *feeling* when the formed cut runs into the parallel bore of the work. Tapping, which now forms an operation by itself, was attempted as one of the suboperations of this operation, but was abandoned. Collapsible taps were used, but were very unsatisfactory, as the taps tried would not stand up to the work.

THE LATHE AND TURRET

In Fig. 39 are shown the changes made on one of the engine lathes to fit it for the work in hand. As practically



OPERATION 7: BORE, REAM, FACE, NOSE TO LENGTH AND PROFILE BORE INSIDE OF NOSE

Machine Used—Engine lathe
Special Fixtures and Tools—Collet chuck A, profile cam B, Armstrong boring tool for suboperations 1 and 5; special boring bar for suboperation 2; special reamer and arbor for suboperation 3; special facing cutter and arbor for suboperation 4
Gages—Plug gage for hole
Production—From one machine and one man, 4 per hr.
Note—Soap-water lubricant
References—See Figs. 38, 39, 40 and 41

all the lathes were either of different makes or different sizes, it will be readily appreciated that a large amount of work was necessary to fit them for their duties. The cam slot embracing the cam roll has been found entirely satisfactory. There is very little wear between the roller and

turret with all unnecessary finish left out. After all the work of fitting the parts together and fitting the base to the bed of the lathe is finished, the tool holes are bored in the usual way with a tool held in the live spindle. This insures accurate alignment, without spending time unnecessarily on accurate spacing of the index slots.

In Fig. 41 the boring bar, reamer, reamer holder and facing bar and tool are shown in detail, together with the plug gage for the hole.

The output for one lathe and operator is about four per hour at present, but the job is new and as the men become accustomed to the work will probably be increased considerably.

TAPPING ON THE RADIAL DRILL

The eighth operation is performed on a radial-drill press, as shown in Fig. 42. It is a simple tapping job, requiring neither special skill nor special accessories.

The work *A* is gripped in the work holder *B*, shown in detail in Fig. 43. Several of these are used at various stages of manufacture. The tap *C* and tapholder *D*, together with the plug thread gage, are also shown in detail in this same illustration.

Cutting compound is used on the tap. The steel in the shells is very hard and consequently severe on the taps. They have, however, a life of

from one hundred to two hundred holes before they wear too small. About 15 noses are tapped per hour.

From the tapping operation the shells are again run over to the lathe for the ninth operation, which consists of turning the outside to finished size and shape. This

work is done on a number of lathes rigged up as shown in Fig. 44. They have former holders *A* similar to that shown at *G* in Fig. 38, upon which the former cam *B* is secured. The connection between the rest and the former is precisely the same as shown in Figs. 38 and 39. The work is, however, held between centers and not in a collet chuck, and the former conforms to the shape of the

limit snap gage for the body size of the shell; but as this was shown in Fig. 25, among the gages used in the fourth operation, it will not be necessary to reproduce it here. No mention has heretofore been made of each operator stamping his work. This detail of manufacture is so well known that statement of it is really superfluous. In this operation, however, the workman performs several acts

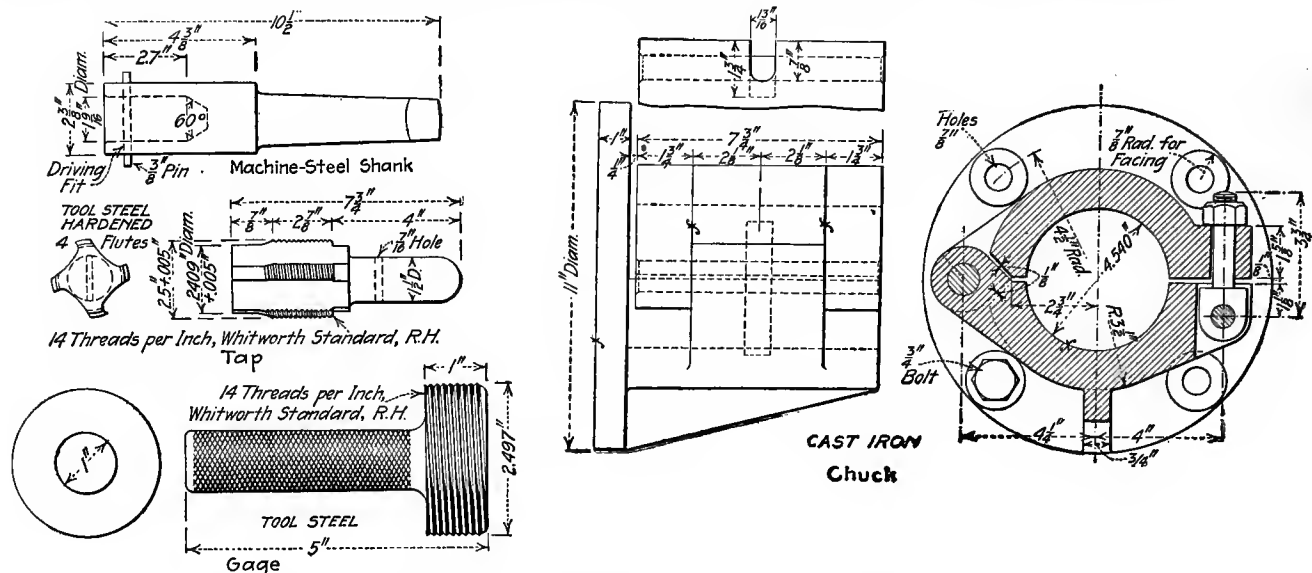


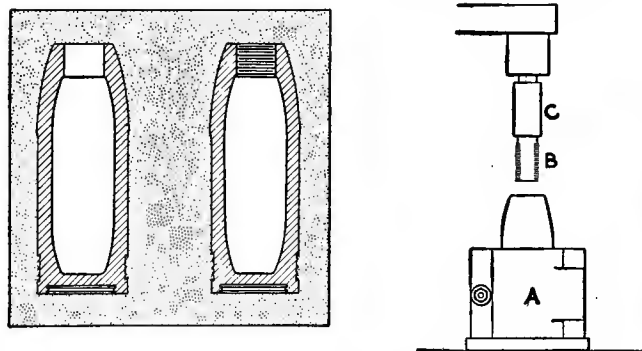
FIG. 43. WORK HOLDER, TAP, TAPHOLDER AND THREAD GAGE FOR SHELL NOSES

exterior of the shell. The screw plug *C* shown in detail in Fig. 45 is screwed into the nose of the shell and fitted with a dog. The base end of the shell is supported by the female center *D*, also shown in detail in Fig. 45. An ordinary turning tool is secured in the tool post. The operator first runs a roughing cut from *E* to *F* over the nose of the shell. This cut averages about $\frac{3}{32}$ in. in depth

while the cut is running, and this being one of them is deemed worthy of notice. The production per lathe is a little more than four per hour. After stamping, the shell is carried to the inspection bench, where it undergoes the first inspection.

FIRST SHOP INSPECTION

On the completion of the ninth operation and removal of the threaded driving plug each shell is brought to the inspector's bench to undergo the first shop inspection, which forms the tenth operation.



OPERATION 8: TAP NOSE OF SHELL FOR SOCKET

Machine Used—Radial drilling machine.
Special Fixtures and Tools—Special work holder *A*; special tap *B*; special tapholder *C*.
Gages—Plug thread gage.
Production—From one machine and one man, 15 per hr.
Note—Soap-water lubricant.
References—See Figs. 42 and 43.

and prepares the whole of the body of the shell for the finishing cut, which starts at *G* and runs to *F*. It will perhaps be remembered that the part from the face of the base to *G* was turned to finished size, and the part from *G* to *E* was rough-turned in the fourth operation. While the finishing cut is running from *G* to *F* the operator removes the screw-plug *C* from the shell previously finished and screws it into another shell. He also stamps the shell with his symbol, so that imperfect work can be traced to him. Each operator on this work is provided with a

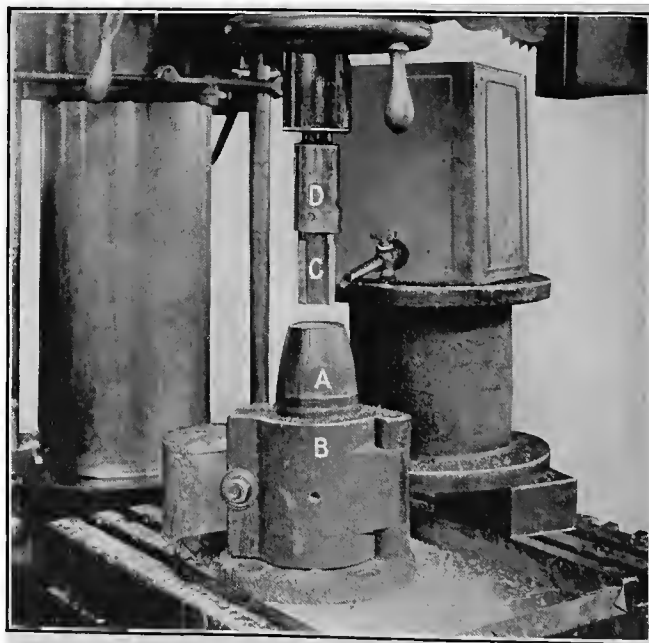
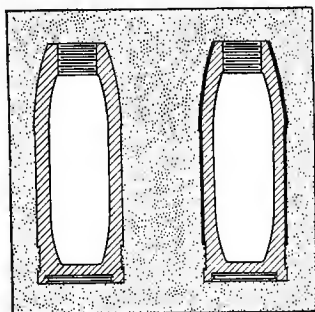


FIG. 42. TAPPING THE SHELL NOSES

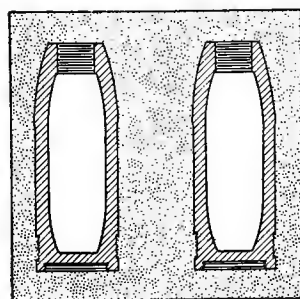
The implements and gages used in this operation are shown in Fig. 46. The body is first tested with high and low snap gages, 4.480 and 4.460 in. respectively. These gages are among those shown in Fig. 25. The high and low ring gages *A*, also 4.480 and 4.460 in. respectively, are then tried over the body. The nose gage



OPERATION 9: FORM TURN OUTSIDE TO FINISHED SIZE

Machine Used—Engine lathe.
Special Fixtures and Tools—Threaded driving plug *A*, female center *B*, former *C*.
Gages—Limit snap gage for body size.
Production—From one machine and one man, 4 per hr.
Note—Soap-water lubricant.
References—See Figs. 44 and 45.

B with high and low limits is tried on the nose. The head profile gage is also tried on the shell nose to see whether it is in conformity. The length gage is for testing the length of the shell minus the socket. The gage for testing the thickness of the gage is worthy of note. The shell is inverted and slipped over the ver-



OPERATION 10: FIRST SHOP INSPECTION

Machine Used—None.
Special Fixtures and Tools—Weighing scales.
Gages—For diameter and shape.
Production—One inspector can examine 20 shells per hr.
References—See Figs. 45 and 47.

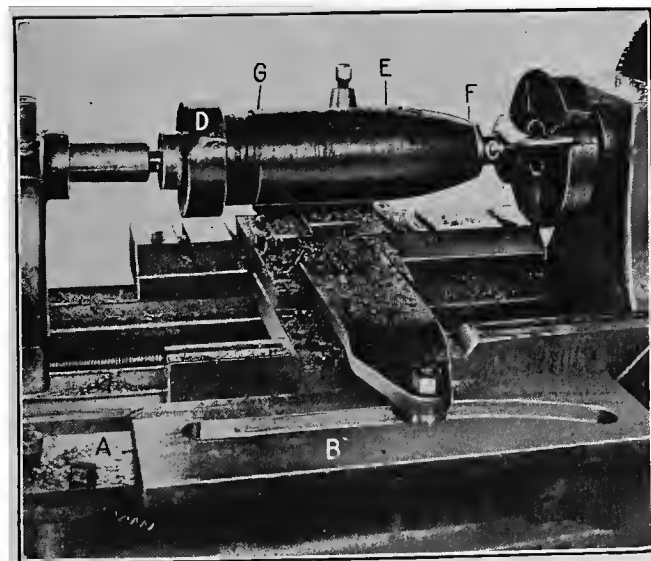
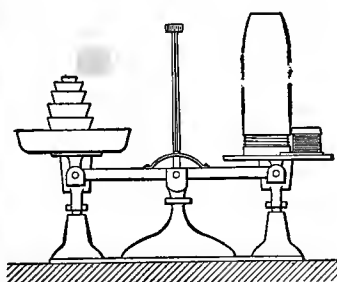


FIG. 44. FORM-TURNING THE SHELL TO SIZE AND SHAPE FOR THE NINTH OPERATION

tical standard, after which the swinging member is swung to rest on the base of the shell. The method of using the gage for measuring the thickness of the side shown in Fig. 46 is self evident and requires no further explanation.

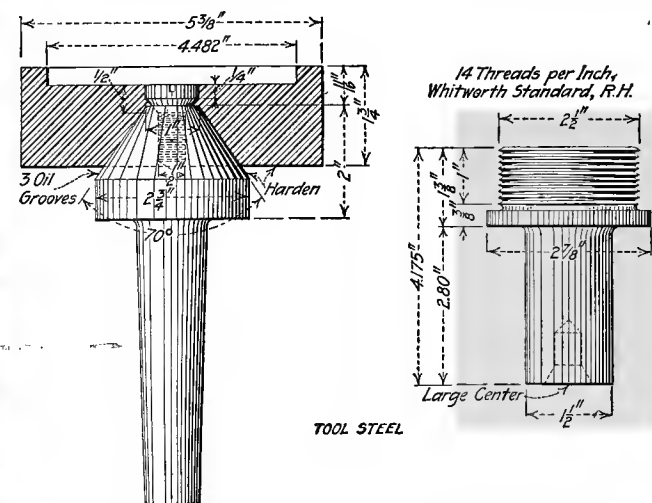
To revert for a moment, the heat number which was stamped on the original cast billet, and subsequently on the forging, must always find a place on the work as it passes from one stage of manufacture to another. On the completion of the fourth operation it is stamped in the wave groove, for here it is safe from effacement till it is covered by the copper band. At no other place on the shell would this be the case, for all other parts of the exterior of the shell are subjected to either machining or nosing operations. Having passed the various gagings, the heat number (stamped in the wave groove) is transferred to the body of the shell, which is now finished, this being its final location.

The shell is next placed on the scales. On the one pan are the necessary weights and on the other a base plate of finished size and a finished socket, for the weight of each complete shell must include these two parts. The weight requirements are that the shell at this stage must not weigh more than 27 lb. nor less than 26 lb. 12 oz. On



OPERATION 11, WHICH IS NECESSARY IN ONLY ABOUT 50 PER CENT. OF THE SHELLS

Machine Used—Engine lathe same as in operation 7, but without turret.
Special Fixtures and Tools—Collet chuck *A*, profile cam *B*, Armstrong boring tool *C*.
Gages—None. Weight verified by scales.
References—See Fig. 48 and Fig. 39.



leaving the scales the weight of each shell is marked on it with red chalk. The shells pass from the scales in two classes—those that come within the required weight limits and those which are heavier. There are no “too light” shells, for this is a fault which cannot be corrected. The percentage of weight-passing and heavy shells runs about equal. The shells falling within each of these classes are stacked in separate piles. The “passing” shells go through

be made except what is approved by the government department, no order can be taken except on the same terms, and profits are restricted.

That there is not likely to be much unemployment in the engineering trades is suggested by the announcement that there are already set up 16 national arsenals and 11 more are in the course of construction. To run these works and equip them and others 80,000 more skilled men

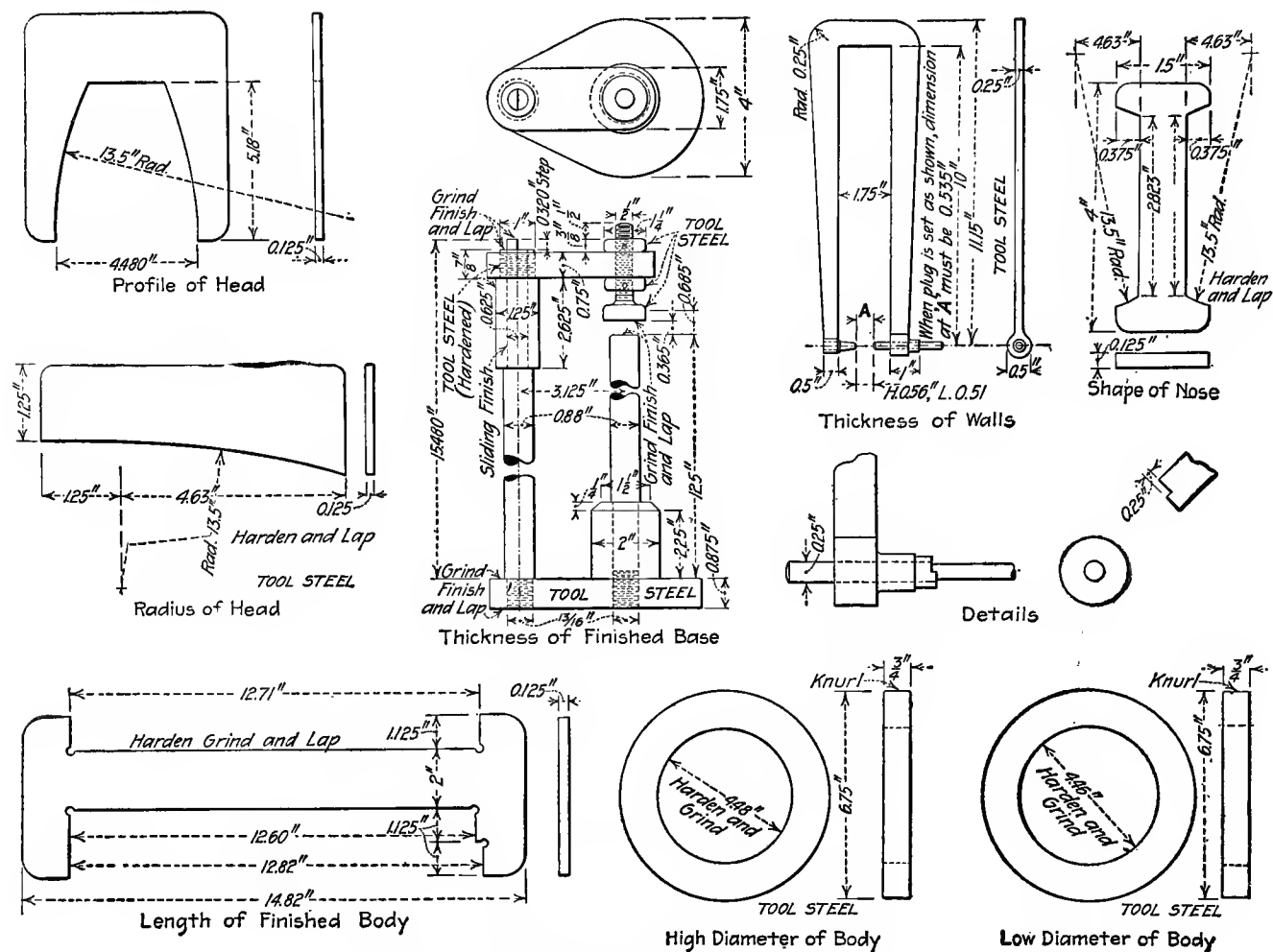


FIG. 46. GAGES USED IN FIRST SHOP INSPECTION

to completion, while the heavy shells are brought to passing weight by an extra operation.

BORING TO WEIGHT

The eleventh operation consists of form-boring the inside of the shell. The equipment is exactly similar to that used in the fifth suboperation of operation 7. Engine lathes equipped with a form-boring cam, as shown in Fig. 38, are used. The turret is dispensed with, but the boring tool in the tool post is used. The men employed on this work have become so expert that a single cut almost invariably brings the shell to correct weight. After this operation the shells are again weighed and if found correct are stacked with the passing shells.

War Material and Workmen

That the toolmaking industry of Great Britain is under government control has been officially confirmed by the Minister of Munitions. Roughly, no machine can

and 200,000 more unskilled men and women will be wanted.

Some 715 establishments are controlled. The number of government-controlled engineering shops is gradually increasing and on the whole the system is being introduced with a minimum of friction. The production of shells and related munition work is steadily increasing, much of the early preparatory work now showing in the results.

Some progress is being made with the organization of amateur munition volunteers owning foot lathes, who, at home, will produce simple parts, etc., under an arrangement with the controlled works, by which usual piecework prices will be paid. After distribution and collection expenses are defrayed any surplus is handed to Red Cross funds, the amateurs, of course, giving their services.

In order to hasten output of the various shops, the munitions committee is giving especial attention to the introduction of female labor.

Manufacturing British 4.5 High-Explosive Shells--V*

By E. A. SUVERKROP

SYNOPSIS—The shell, having passed the shop inspection, is now prepared for the preliminary government inspection by having the base-plate recess threaded and the body cleaned and sand-blasted inside and out. The base plate, which is a separate forging, is turned, faced and threaded to fit the threaded base-plate recess.

After passing shop inspection the work goes to the threading operation. This is done on 2-in. Jones & Lamson flat-turret lathes as shown in Fig. 47. The shells, it will be remembered, were recessed for the base plate in the Warner & Swasey lathes in the fourth operation.

shown in detail in Fig. 51. The rollers are mounted on eccentric studs so that they can be adjusted to hold work varying slightly in size from piece to piece.

THREAD-CHASING ATTACHMENT

The thread-chasing attachment shown in Fig. 47 is an example of clever design. The splined rod *D* is driven through gearing from the live spindle of the lathe. At *E* is a clutch, so that the rotation of *D* can be stopped or started at the will of the operator without stopping the spindle of the lathe. Running in the upright *F* is a vertical shaft driven by *D* through spiral gears. The upper part *G*, in which these gears are located, has a stem projecting downward into a bearing in *F*, in which it is free

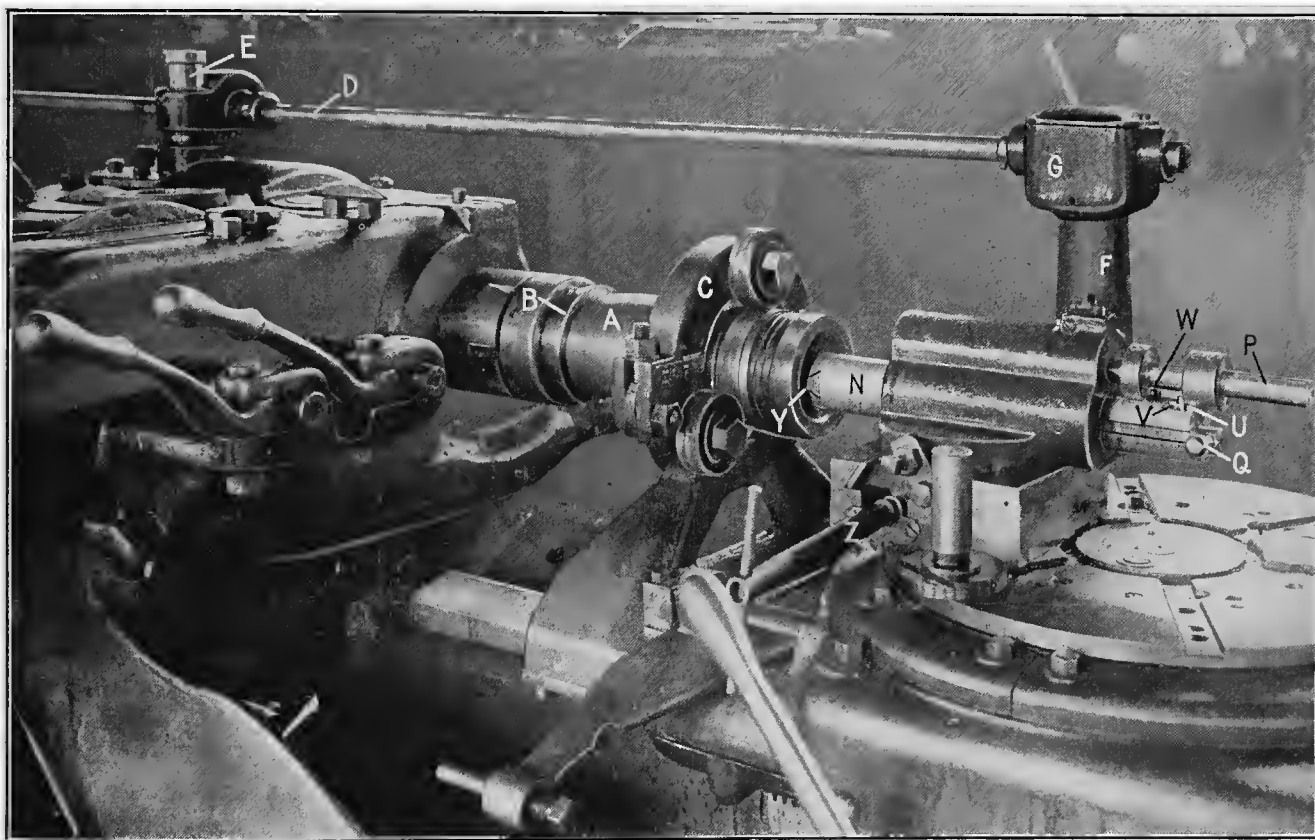


FIG. 47. THREADING BASE-PLATE RECESS ON FLAT-TURRET LATHES

The recessing tool in that operation leaves the work the correct size for threading. The thread-chasing attachment is made by the makers of the machine, but the method of holding the shell and the crossfeed for the attachment were developed in the works.

The work *A* is held in a special draw-in chuck *B* designed and built in the works. This chuck with slight modifications has been successfully applied to a number of lathes in the shop. It is shown in detail in Fig. 50. The forward end of the shell is supported in the roller steadyrest, also designed and built in the works and

to turn in a horizontal plane. The member *E* can also turn horizontally.

The splined driving shaft *D* is provided with collars on each side of *G* so that it has no endwise motion with relation to *G*. It is, however, free to slide endwise at *E* in its bearings and in the spiral gear. This feature, with the two horizontally rotatable supports at *E* and *G*, makes possible the rotation of the flat turret when the machine is used for more than the threading of the base-plate recess, although in this particular case it is not so used. In Fig. 48 is shown sufficient of the internals of the thread-chasing attachment to make clear its operation. In this illustra-

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tion the same reference letters will be used as in Fig. 47 wherever possible.

At the lower end of the vertical shaft in *F* (Fig. 47) is another spiral gear shown at *H* in Fig. 48. This gear is rigidly secured to its shaft *I*. Near the end of the shaft

The chasing bar *N* is bored lengthwise to receive a bar terminating at one end in the ball handle *Q*. This bar is cylindrical except for a flat formed on a part of its circumference. This flat part is under the half-nut *R*. A rounded groove *S* in *N* permits the lead screw *P* to

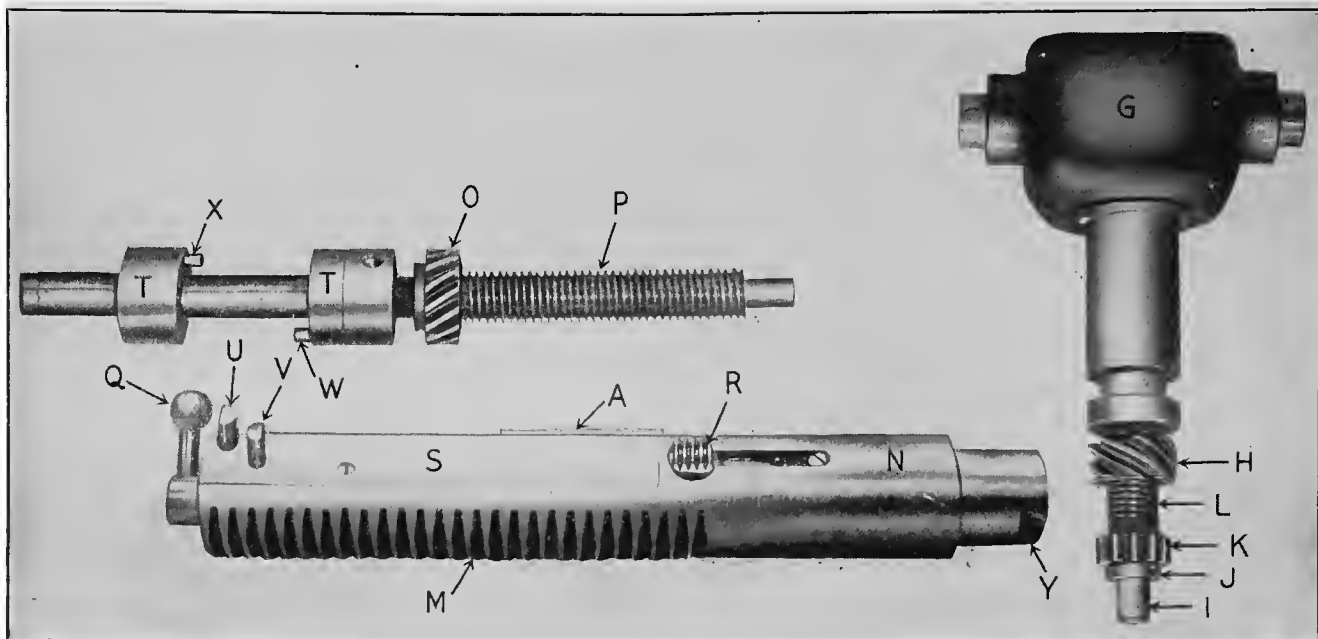


FIG. 48. DETAILS OF THE THREAD-CHASING ATTACHMENT

is a collar *J*, also rigidly secured to *I*, and above it a spur pinion *K*. This pinion is loose on the shaft *I*, but a heavy spring *L* holds it in frictional contact with the collar *J*, so that it will transmit a drive sufficiently powerful for the purpose at one part of the cycle of the threading

be placed close to *N*. It is deep enough to clear the collars *T*. At *U* and *V* are two pins. On the inside of *N* these pins engage the bar (previously referred to) with the flat on it. The collars *T* on the lead screw are dis-

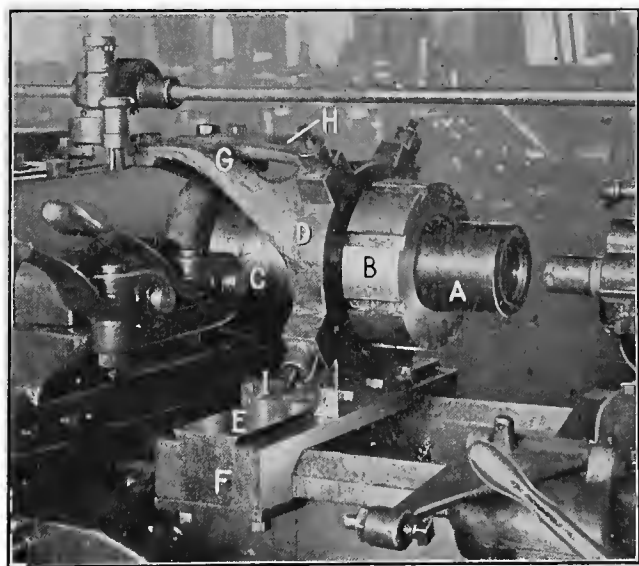
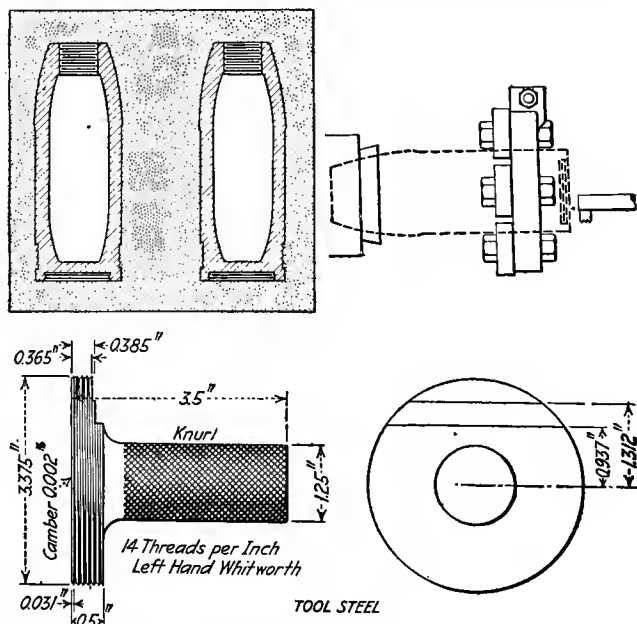


FIG. 49. CROSS-SLIDING HEAD TO HOLD 4.5 SHELLS FOR THREAD CHASING.

operation, but will slip at that part of the cycle when it is its duty to slip.

The spur pinion *K* engages the rack *M* on the cylindrical chasing bar *N*, and the spiral gear *H* engages the spiral gear *O* on the lead screw *P*. The relative positions of the members *N* and *P* under working conditions are best shown in Fig. 47.



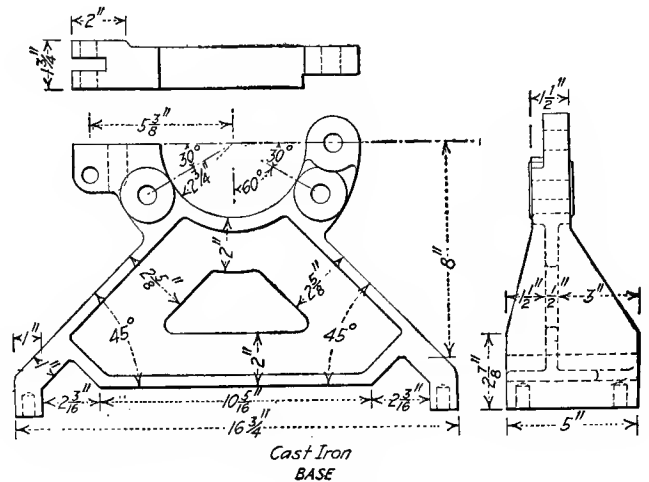
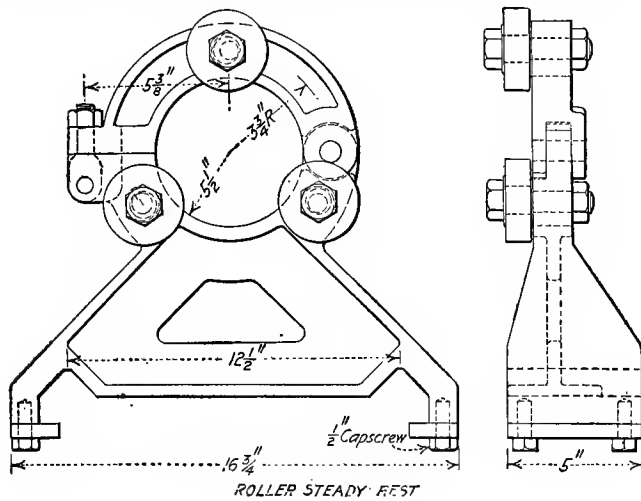
OPERATION 12. THREADING THE BASE-PLATE RECESS
Machines used—2-in. Jones & Lamson flat turret lathes.
Special fixtures and tools—Jones & Lamson thread-chasing attachment. Draw-in chuck. Roller steadyrest.
Gages—Thread gage of the plug type.
Production—From one man and one machine, 16 per hour.
References—See Figs. 47, 48, 50, 51 and 52.

posed, one on each side of these pins. Each collar has a pin *W* or *X* disposed vertically to its face. These pins *W* and *X* are so located that when in a favorable position only one of them can strike one of the pins *U* or *V*. When

the pin *U* is struck by the pin *X* the inner bar is turned in the chasing bar *N* so that the cylindrical part is under the half-nut *R*. This raises the half-nut *R* into operating position in mesh with the lead screw *P*. When the pin *V* is struck by the pin *W* the inner bar is turned in the chasing bar *N* so that the flattened part is under the half-

movement, but rotates at the speed correct relatively to the spindle speed, as in any other thread-cutting operation where a lead screw is used.

The chasing bar *N* is, as stated, traversing from left to right, and the half-nut *R* is out of engagement with the lead screw *P*. Referring to Figs. 47 and 48, when the



bar *N* has retreated far enough the pin *U* in it arrives at a position where the pin *X* in the collar of the rotating lead screw strikes it and forces it down. This causes the bar in *N* to rotate. The cylindrical part at the middle of the inner bar lifts the half-nut *R* into engagement with the lead screw *P* and the lead screw feeds the chas-

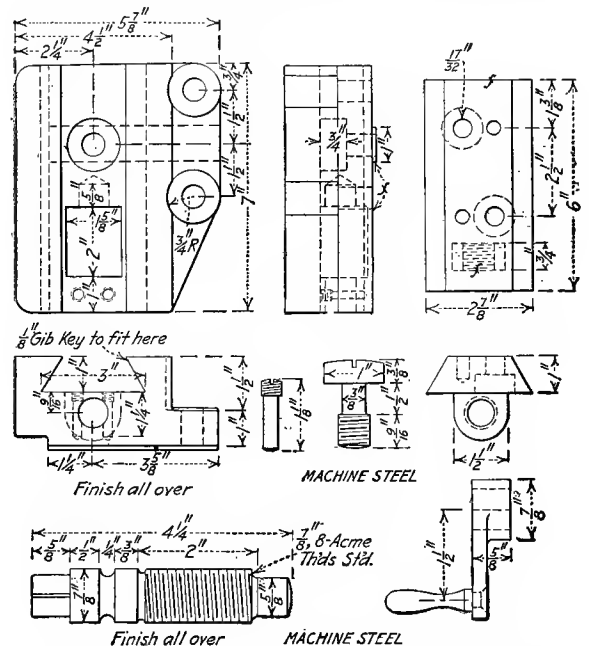


FIG. 51. ROLLER STEADY REST

nut *R*. This permits the half-nut to drop out of engagement with the lead screw.

The chasing bar *N* is a sliding fit in its housing and is held from turning by a feather shown at *A* in Fig. 48. The fixture is so set that the bar *N* at its extreme forward traverse carries the chaser *Y* to the bottom of the base-plate recess.

On the forward end, that is, the end of the inner bar most remote from *Q*, is an eccentric pin which, working in a crosswise slot in the body of the chaser *Y*, throws it in or out of cutting position.

OPERATION OF CHASING A THREAD

We will imagine that the fixture has been set properly with relation to the work, that a cut has already been taken and that the bar *N* is returning from the bottom of the base-plate recess; that is to say, is moving from left to right, with the chaser *Y* clear of the work. The mechanism that controls this part of the cycle will be described in its proper place. The lead screw *P* has no endwise

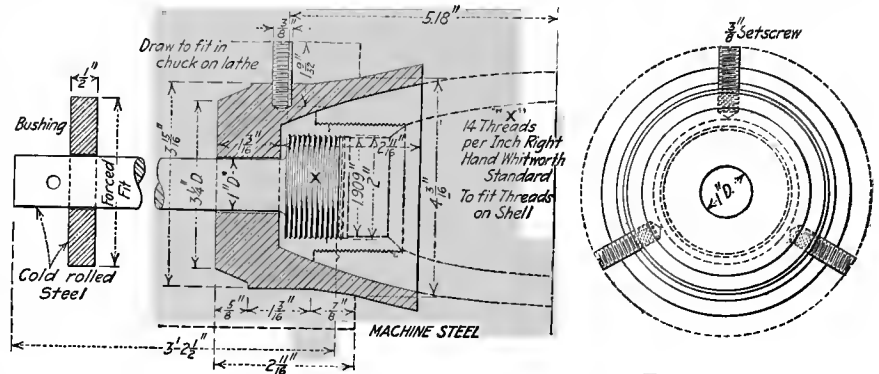
ing bar *N* forward at the correct speed to cut the thread. Simultaneously with the lifting of the half-nut *R*, in the middle of the chasing bar *N*, the eccentric on the end of the inner bar assumes a position that sets the chaser out to cutting position. The direction of rotation of the pinion *K*, which meshes with the rack *M* of the chasing bar, would tend to move the bar *N* from left to right while the lead screw *P* is forcing it from right to left. This is where slipping of the spring-controlled friction *L* takes place.

The chasing bar *N* is forced by the half-nut and lead screw to move from right to left and the chaser to take a cut while the friction slips. When the chaser in the end of the chasing bar *N* reaches the bottom of the base-plate recess, the pin *V* in the chasing bar is in position to be struck by the pin *W* in the lead-screw collar. This rocks the inner bar in *N* so that the flat is under the half-nut *R*. The half-nut *R* having nothing to support it, drops out of engagement with the lead screw. The friction pinion *K* being relieved of the opposition of the lead screw, racks the chasing bar *N* back from left to right as before. Simultaneous with the release of the half-nut *R* the eccentric on the end of the inner bar withdraws the chaser from cutting position so that it clears the work on the return of the chasing bar *N*.

During the threading operation the lathe is run backward as the base-plate thread is left-hand. The pitch is 14 per inch and the Whitworth form of thread is required. More kicks are heard about the difficulty of making accurate threading tools to this standard than about any other detail connected with shell-making.

Referring to Fig. 47 it will be noted that the fixture is secured to a base slide fastened to the turret. The slide is shown in Fig. 52. The feed for each individual cut

The way the problem has been solved by another designer is shown in Fig. 49. The work *A*, approximately 4.5 in. diameter, is too large to go into the hole in the spindle, so it is held in a collet chuck *B* mounted on the end of the spindle extension *C*, which is made large enough in the bore to take the shell. The inner end of the exten-



nose down in orifices in special cast-iron trays shown at *A* in Fig. 53. Each tray holds 50 shells, as shown at *B*. On each side two lugs project from the sides of the tray. These serve two purposes—as a seat for the 4 eye-bolts used to lift them by, and to support the weight of the tray and shells when being transported in trucks from one part of the shop to another. Two kinds of trucks are

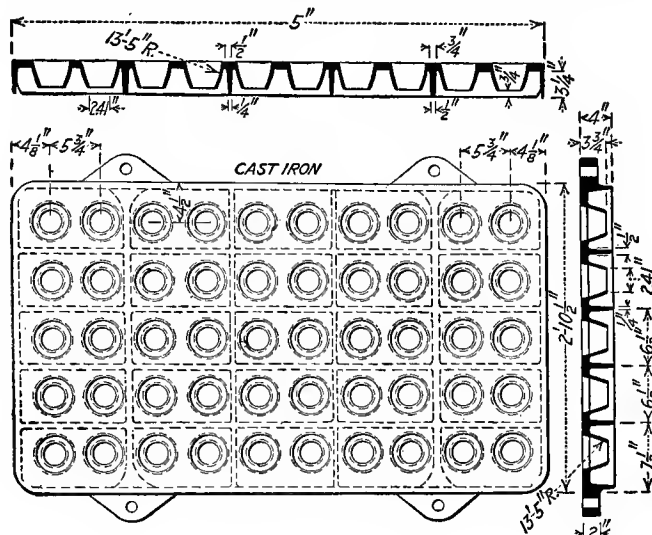


FIG. 54. DETAILS OF THE CAST-IRON TRAY

used: For ordinary transportation purposes the body is made of wood; the part in which the cast-iron tray nests is built in the shape of a hollow rectangle with sides and ends made of 3x4 hardwood. The trucks used in the baking operation are of iron, with raised sides to support the trays. Details of the cast-iron trays are shown in Fig. 54.

Since the shells come from the soda tanks very hot and are stood on end with their open ends downward in the trays *A*, they are thoroughly dry by the time they

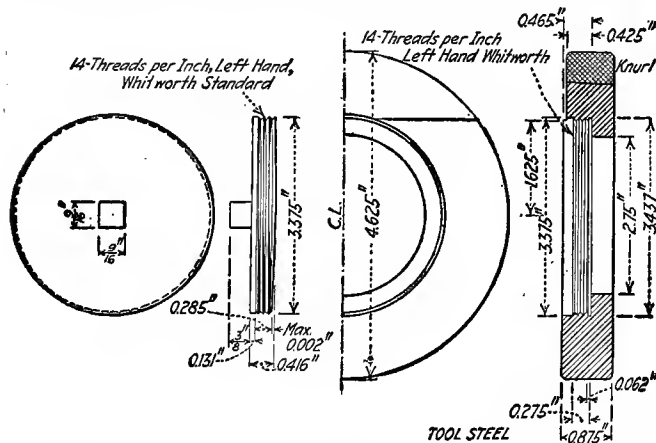


FIG. 55. BASE PLATE FOR 4.5-IN. SHELL AND INSPECTION GAGE

reach the sandblast room. Here the trays are lifted from the trucks to the table by the air hoist *C* and a chain span with 4 hooks in the eye-bolts.

With the bent nozzle *D* they are thoroughly sandblasted both inside and out. It is particularly necessary that they be absolutely clean on the inside so as to have a good surface for the application of the copal varnish in a later operation. After being thoroughly sandblasted the dust is blown off with air alone and the shells taken to have the base plates inserted.

The Government specifications require that all high-explosive shells shall be fitted with base plates. The duty of the base plate is effectually to stop off any pipe or fissure in the base of the shell forging and thus prevent premature ignition of the explosive charge by the propulsive charge. To eliminate the possibility of pipes occurring in both base plate and shell and the remote possibility of these coinciding when assembled and thus offering unobstructed passage for flame from the propulsive charge to the explosive charge, the base plates must be made with the grain of the metal at right angles to the axis of the shell.

Details of the methods of forging and rough-finishing the forging in the shops of the Canadian Car and Foundry Co., Montreal, Canada, were given on page 89, Vol. 43.

Since the war started several types of machine have been developed or adapted to handle the work of finishing base plates.

In the works of the Allis-Chalmers Co. base plates are machined by two methods—the semiautomatic machines built by the Automatic Machine Co., Bridgeport, Conn.,

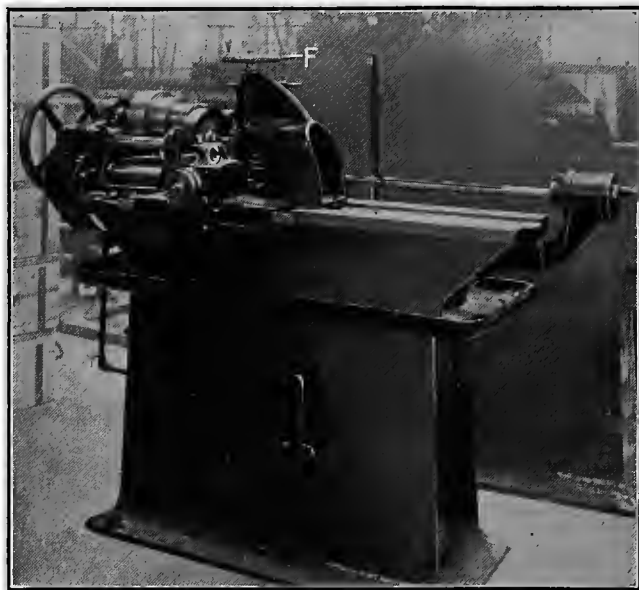


FIG. 56. SEMIAUTOMATIC MACHINE FOR TURNING AND THREADING BASE PLATES

and the ordinary engine lathes. The latter are used because the demand for base plates exceeds the output of the semiautomatic machines installed.

In Fig. 55 is shown the 4.5-in. base plate and the base-plate inspection gage. The semiautomatic base-plate turning machine is shown in Fig. 56; and an enlarged view of the work and the tools in Fig. 57.

SEMIAUTOMATIC BASE-PLATE TURNER AND THREADER

The work *A* is held in a collet chuck. At the back is the turning tool held in the tool post *B*, while at the front is the threading tool held in the tool post *C*. The action of both these tools is automatic. That is to say, the tool is fed to depth, traverses the work, is run back clear of the work and returned to the starting position when the cycle of operations is repeated till the piece is turned to diameter. The threading tool then takes up its series of operations while the turning tool is clear of the work. The facing tool *D* is held in the vertical slide *E*. It is fed by hand, using the handwheel *F*, Fig. 56. The slide for this

tool is set at a slight angle to give the camber of 0.002 in. specified.

The work *A* is chucked in the collet chuck, and the machine is started. The turning tool at the rear of the machine then begins the cycle of its operation. In the mean-

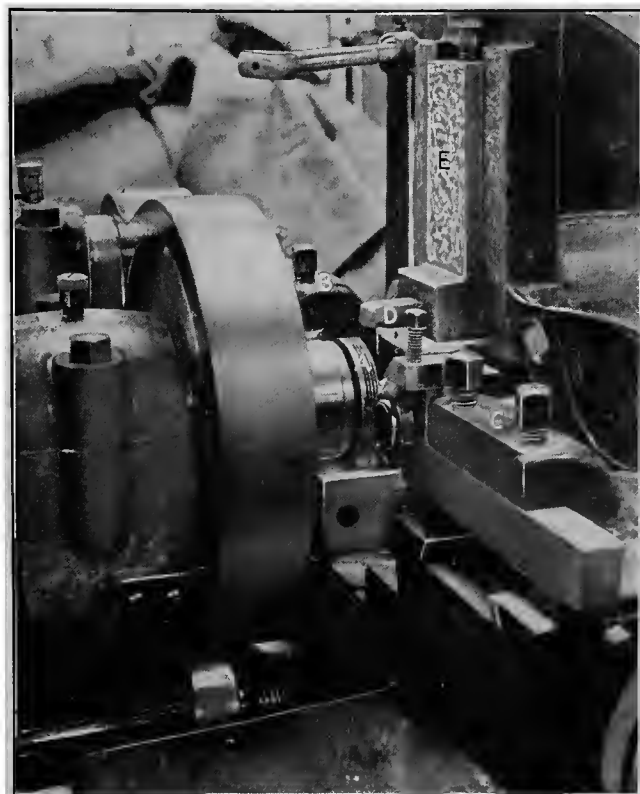


FIG. 57. ENLARGED VIEW OF WORK AND TOOLS

time the operator feeds the tool *D* vertically toward the center of the disk. By the time it has reached the center the turning tool at the back has taken the requisite number of cuts, usually three. When the turning tool has finished

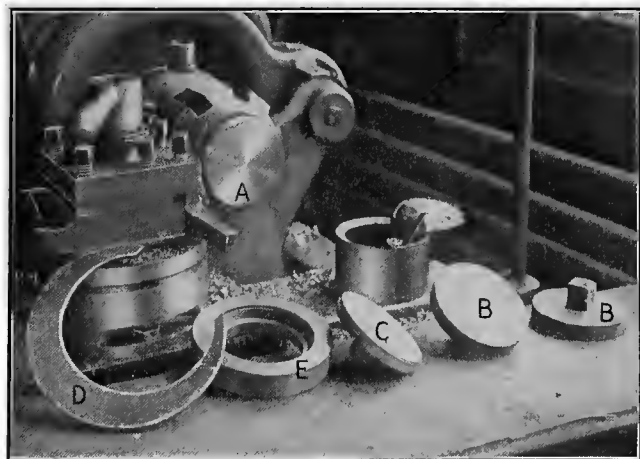
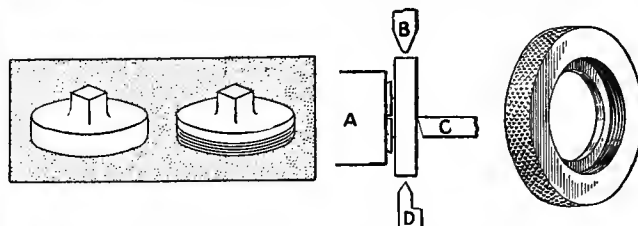


FIG. 58. TURNING AND THREADING BASE PLATES

its work the slide is tripped and the tool backs out. Simultaneously the threading-tool slide is tripped and starts the cycle of its operations. The threading tool is advanced to the cut, traverses the cut, is withdrawn clear of the work and returned to starting position, when the same cycle of operations is repeated. About six cuts are required to finish the thread. On completion of the thread

the machine is automatically tripped. A machine and operator finish about 8 base plates per hour.

In Fig. 58 is shown the set-up of an engine lathe for turning and threading base plates. The photograph for this illustration was taken in another factory. The work *A* is gripped in a collet chuck. The turret tool post is equipped with facing, turning and threading tools. At *B* are two base plates in the rough and at *C* a finished one. At *D* is the snap gage for outside diameter and at *E* the gage for the finished base plate. Owing to the fact that the thread is left-hand the job is easier to thread than if it were right-hand. However, owing to the Whitworth



OPERATION 14. TURN AND THREAD BASE PLATE

Machine used—Bridgeport semiautomatic lathe.
Special fixtures and tools—Draw-in chuck *A*. Turning tool *B* at back. Hand-operated facing tool *C*. Threading tool *D* at front.
Gages—Ring type thread gage.
Production—One man and one machine, 8 per hour.

thread it must be finished with a chaser, as the single-pointed tool will not round the points of the threads. The time made with this set-up was not very satisfactory; the operator was able to turn and thread only 3 per hour.

❧

German Shell Forging Practice

In the shell-forging practice followed at the Rheinische Metallwaren-und Maschinenfabrik, Dusseldorf-Rheinland, Germany, a square piece of steel is used.

In making a shell forging a square piece of steel is used, the corners loosely fitting the circular form of the die. The advantages of using square stock are that it will center itself and the metal will more readily spread out when the punch enters, thereby saving power and also lengthening the life of punch and die. It is claimed that this does not make so strong a forging as when round stock is used, but the fact that the Ehrhard product is considered one of the best should show that square stock answers the purpose when the right kind of material is used.

The material for the punches is round bar steel, cut off hot to length; not as difficult to machine as high-carbon steel, but harder. The chips all break off short, are glassy looking, with shiny spots in them, and of course yellow or blue. The high-speed steel used at this plant is all of their own make forged to shape and air hardened.

The press being set up, the square stock is heated to a white heat and, after brushing off is placed in the die. The power is then applied and the punch descends to the required depth, the material creeping up on the punch after filling the die hole. Before withdrawal a stripper, open on one side, is swung into place and strips the forging. The height of the stripper is such that it does not act before the shell is out of the die, the working length of press allowing for this. While one man operates the press, another grasps the shell with a tongs as it drops off the punch.

Manufacturing British 4.5 High-Explosive Shells--VI*

By E. A. SUVERKROP

SYNOPSIS—The shells now have the base plates fitted and undergo the preliminary Government inspection. Having passed this, the base plates are screwed in to stay, the bases are faced off, the sockets are screwed in permanently and the outside of the sockets turned to finished shape.

The next operation is fitting the base plates. The shells are held nose down in a clamp holder as in Fig. 59. The clamp holder is shown in detail in Fig. 43. The block A is a piece of 12x12 yellow pine cemented into the concrete floor. The wrench handle and pipe together form a lever about 6 ft. long and two men do the job, so a rigid support for the clamp holder is necessary.

A drop of Pettman cement is daubed on the center of the cambered face of the base plate. This cement is very similar to red-lead cement, but is made of red oxide of iron as no lead is permitted to form any part of the high-explosive shell. The oxides of lead in contact with the picric acid in lyddite form picrate of lead, a very unstable compound liable to spontaneous decomposition. For this very good reason the Pettman cement with its iron base is used.

The base plate is then screwed down hard and the drop of Pettman cement acts as a witness and proves the fit. The shells next go to the preliminary Government inspection. This inspection is carried out in the inclosure shown in Fig. 60. While no previous mention has been made of the work of the Government inspectors, their duty is to follow the work through the entire course of manufacture. Wherever an inspection mark must be effaced in

the course of machining it is their duty to replace it on the shell.

It would, therefore, perhaps be as well to go over the work that has been done by them before the preliminary inspection is taken up.

GOVERNMENT INSPECTORS' DUTIES

In the Allis-Chalmers plant, at this writing, the work is taken care of by a chief inspector and four assistants. When the hollow forgings are received at the works a

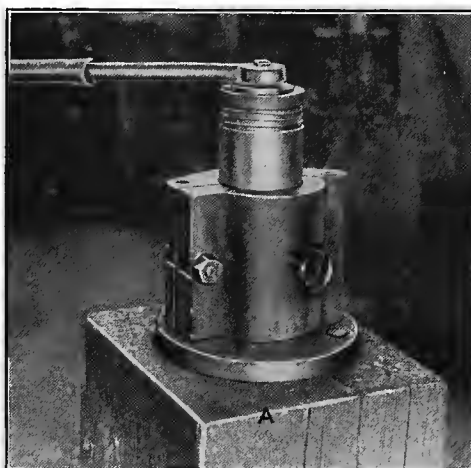


FIG. 59. SCREWING IN BASE PLATES

Government inspector goes over them to see that they bear the acceptance mark of the inspector of steel. This mark is a diamond with the well-known British "broad arrow" within it.

The inspector's acceptance mark is removed during the facing operation; he therefore superintends the facing of

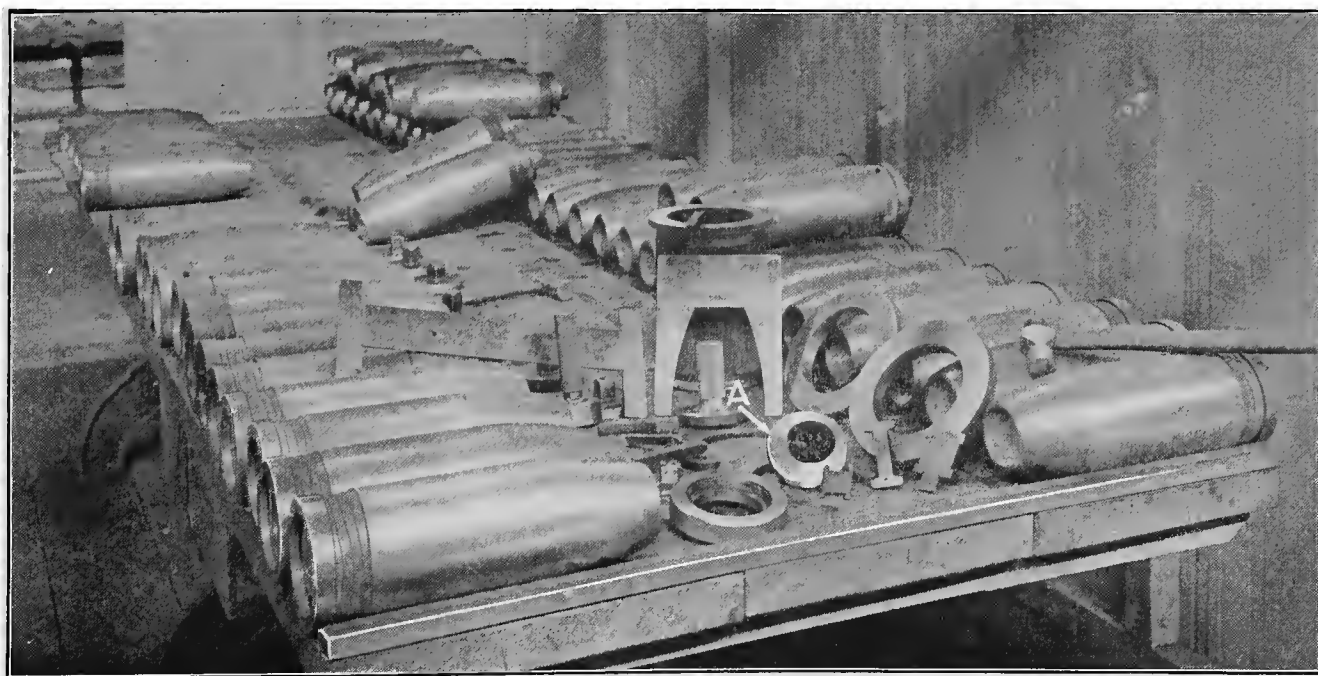


FIG. 60. A GROUP OF SHELLS READY FOR PRELIMINARY GOVERNMENT INSPECTION

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the shell bases and transfers the acceptance mark (stamped by the inspector of steel) to the head of the shell above the shoulder. Under his direction the contractor transfers the steel maker's cast and ingot numbers to the head of the shell.

After the heading operation is completed on a "lot" of 4.5-in. shells, the lot is stacked and an inspector selects

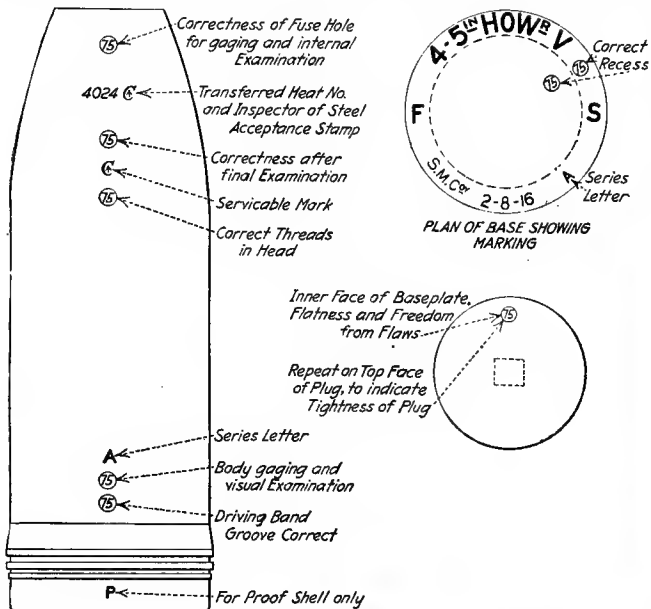


FIG. 61. MARKING FOR ACCEPTED SHELLS

one shell for the compression and tensile tests required by the specification. It is his duty to check the number of shells in a lot and see that all bear a lot mark on their bases. The selected shell is taken by him to the employee who has been detailed to cut out the test pieces. Should it be impossible to cut the test pieces at once, the inspector returns to his regular duties and takes the shell with him until such time as may be agreed upon when the work of test-piece cutting can be carried out. It is his duty to

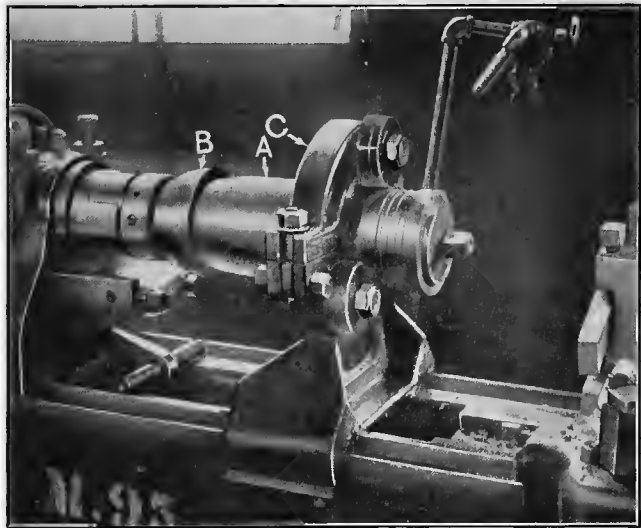


FIG. 62. ROUGH-TURNING THE BASE PLATES ON FLAT-TURRET LATHES FOR RIVETING

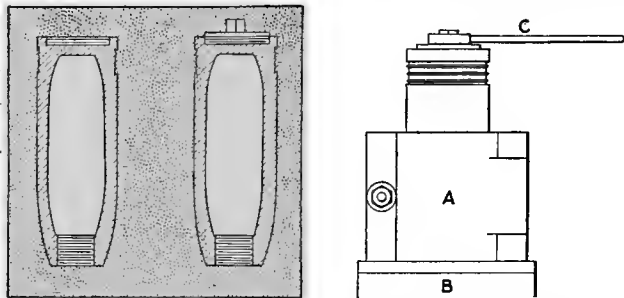
superintend the entire operation of cutting out the test pieces.

When complete the test pieces are stamped with the firm's monogram, the lot letter of the shell and the in-

spector's own work mark. He then personally mails the pieces to the testing center. The shell bodies from which the test pieces have been cut are retained by the inspector until he is authorized by the inspector-in-charge to scrap them. When they are scrapped it is his duty to see that they are so destroyed that no further test pieces can be cut from them. The duty of superintending test-piece cutting as described is carried out by the chief inspector, or an assistant detailed by him. All inspectors take a turn at this duty, but they must not be detailed in any regular order.

PRELIMINARY INSPECTION OF SHELLS

For the preliminary examination, shells with the machined parts finished are presented in lots and inspected for freedom from cracks, flaws, blow-holes, scale, rust



OPERATION 15: SCREWING IN BASE PLATE

Machines Used—None.
Special Fixtures and Tools—Clamp holder A mounted on 12x12 yellow pine post. 6 ft. wrench C.
Gages—None.
Production—Two men about 15 per hr.
Note—Witness mark of Pettman cement on face of base plate.
References—Fig. 43 and Fig. 59.

and other material defects and for smoothness of surface. The operations enumerated in Table 1 are carried out. The steel base plate is unscrewed and examined for flaws and camber, and the recesses are also examined for

Operation No.	Operation	Per Cent. to Be Done, 4.5-In. Howitzer
1	Examination of fractures and work marks on billets.....	100
2	Internal and external examination before varnishing.....	100
3	Undercut in groove for driving band..	100
4	Low diameter of groove for driving band high and low.....	100
5	Examination of threads in head and base.....	100
6*	Concentricity of cavity.....	100
7	Depth and flatness of recess for base plate.....	100
8	Examination of base plates before insertion.....	100
9	Examination of base recess for flaws..	100
10	Base callipers.....	100
11	Wall callipers.....	50
12	Diameter of body (high and low).....	100

*Operation No. 6 is necessary on the 18-pounder only.

flaws and gaged for depth and flatness and also to see that the front thread is cut away correctly. The black spot on the base plate A, Fig. 60, shows how the small spot of Pettman cement has spread.

No patching, stopping, plugging or electric welding is allowed.

Shells found to be correct are marked by the inspector with his work mark in the following manner, illustrated in Fig. 61:

1. A work mark is stamped on the body immediately in front of the driving-band groove to indicate that the groove is correct.
2. A second work mark is stamped above the first if the shell is found correct to body gaging and visual examination. (As an alternative these work marks may be

placed in the rear of the driving-band groove, the one indicating the correctness of the groove being next to it.)

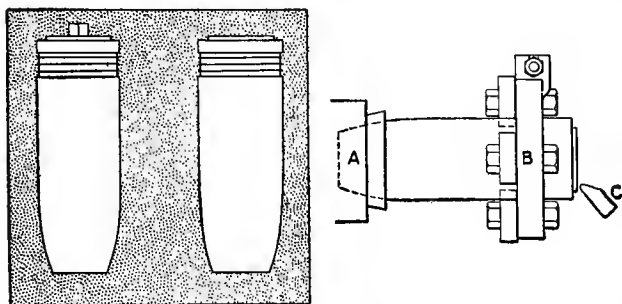
3. A work mark is stamped on the shoulder to indicate that the threads in the head are correct.

4. A work mark is stamped in the bottom of the recess for the base plate and one on the base of the shell near the edge of the recess to indicate correctness of the recess.

5. A work mark is stamped on the inner face of the base plate to indicate flatness and freedom from flaws.

PRELIMINARY SELECTION OF SHELLS FOR PROOF

If the manufacturer desires, a shell may be selected for "proof" at this stage, a distinguishing mark *P* and



OPERATION 16: ROUGH-FACING BASE PLATES

Machines Used—Jones & Lamson flat turret lathes.
Special Fixtures and Tools—Draw-in chuck A, roller steadyrest B, facing tool C.

Gages—None

Production—One man and one machine 18 per hr.

Note—Operation 18 is practically a duplication in methods and speed of this operation.

References—Figs. 50, 51 and 62.

his work mark being put on its base by the inspector. The completion of this shell can now be hastened. When completed it is subjected to the usual final examination and forwarded by the contractor to the Chief Inspector of Arms and Ammunition, Cartridge Factory, Cove Fields,



FIG. 63. RIVETING THE BASE PLATES

Quebec, for proof. The preparation of the shell for proof is done at Quebec.

From the preliminary inspection the shells go back to have the base plate screwed in. This time the entire

threaded end and face of the base plate is brushed with Pettman cement and the plate screwed home to stay.

ROUGH-FACING THE BASE ON THE FLAT TURRET LATHE

The square shank and excess metal in the base plate is cut off in Jones & Lamson lathes, shown in Fig. 62. The shell *A* is gripped by a draw-in chuck *B* similar to the

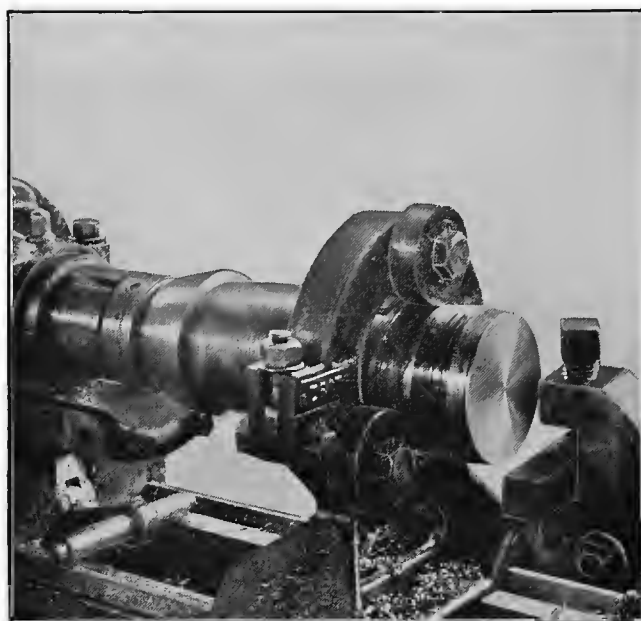
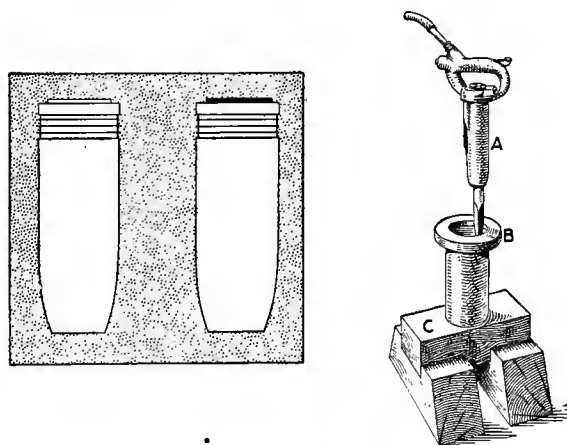


FIG. 65. FINISH-FACING BASES OF SHELLS

one shown in detail in Fig. 50. The body is supported in a roller steadyrest *C* similar to the one shown in detail in Fig. 51.

Although the thread of the base plate is left-hand the lathe is run forward, there being no danger of backing the



OPERATION 17: RIVET BASE PLATE

Machines Used—None.
Special Fixtures and Tools—Pneumatic hammer A, guide ring B, cradle C.

Gages—None.

Production—One man 45 per hr.

References—Figs. 63 and 64.

base plate out for it is screwed home as tight as two men and a 6-ft. wrench can put it, besides which the Pettman cement sets hard quickly and doubtless assists in holding it. The production from one machine and operator is a little over 18 per hour. When the work comes from this operation the base plate is left about $\frac{3}{64}$ in. higher than the base of the shell, so as to provide sufficient metal for riveting, in the next operation.

The first method tried for securing the base plates in the shells was rolling. The attempt was made with a single roller and was not satisfactory. Owing to the camber on the inner face of the base plate, it rocked when the single roller was pressed against it at a point near its perimeter. This stretched the threads on the opposite side and, as the rolling was continuous in a circle, resulted in loosening instead of tightening it in place. I am of the opinion that the job could be successfully rolled by having a pair of rollers mounted on a holder pivoted in the center, the rollers so spaced that each is equidistant from this central pivot and from the axis of the shell.



FIG. 66. SCREWING IN THE SOCKETS

With the rollers pivoted in this manner they would automatically distribute the pressure on both sides of the base plate. There could be no rocking, and the metal would be spread as desired. However, this is beside the question.

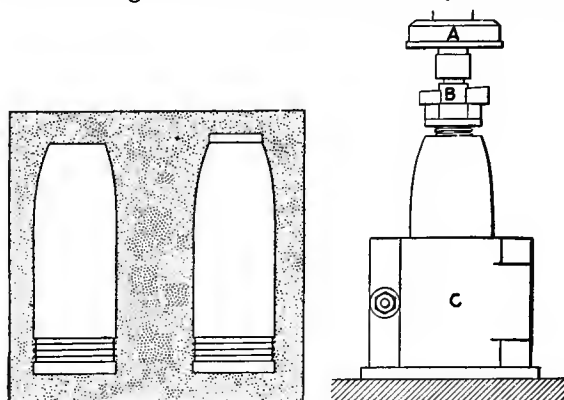
The method used and found satisfactory is shown in Fig. 63. At A is the shell which rests nose down in the hardwood cradle B. A machine-steel guide ring C is placed on top of the base. The operator then manipulates the pneumatic hammer D around in a circle, keeping the curved tool (similar to E) in contact with the ring C. The dimensions of the guide ring are given in Fig. 64. One man can rivet about 45 base plates per hour.

The outfit for finish-turning the base after riveting is practically the same as that used for rough-facing. The production on finish-facing is about the same as on rough-facing; that is, 18 per hour. The bases of the shells as they come from this operation must show no crevice between the base plate and the shell body and there is no trouble in securing this condition.

The brass sockets are next screwed into place. This work is done on a back-gear drilling machine. The work A is held in the clamp holder B (shown in detail

in Fig. 43). The socket C, Fig. 66, is screwed on the end of the driver D, which is provided with the nut E, backed up by the wedge F.

In driving a socket the wedge is entered in the slot as far as it will go. The socket C and the jam E are pre-



OPERATION 19: SCREWING IN SOCKETS

Machine Used—Back-gear drilling machine.
Special Fixtures and Tools—Friction driver A, wedge and nut driver B, special clamp holder C.
Gages—Plug thread gage, to test size of socket after inserting.
Production—One man and one machine 30 per hr.
References—Figs. 43, 66 and 67.

vented from turning on D when the friction between the wedge F and the nut E become greater than the friction between the socket C and the shell nose. When the socket C is screwed to position, the friction G slips, the machine is stopped and the wedge F driven back. This slackens up the nut E, and the driver D is easily backed out.

The upper end of D is squared to fit the friction driver G. Details of the socket driver are shown in Fig. 67. The sockets are painted with Pettman cement before

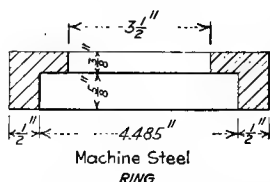
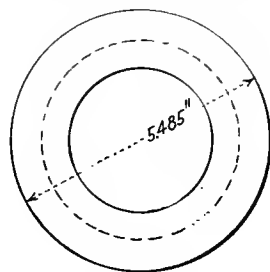


FIG. 64. GUIDE RING FOR RIVETING BASE PLATES

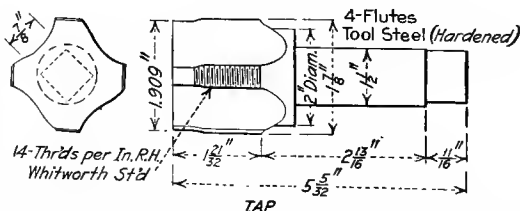
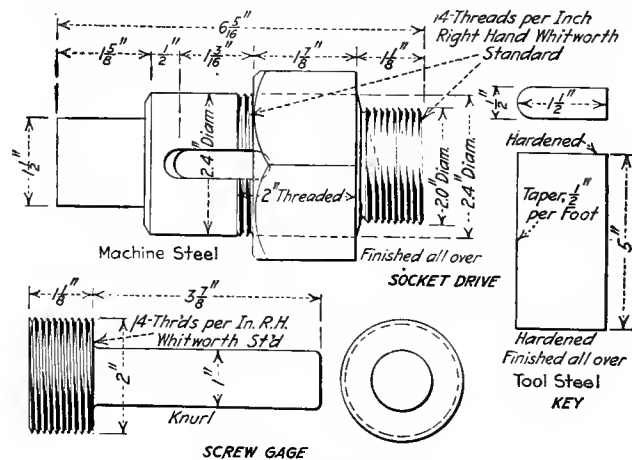
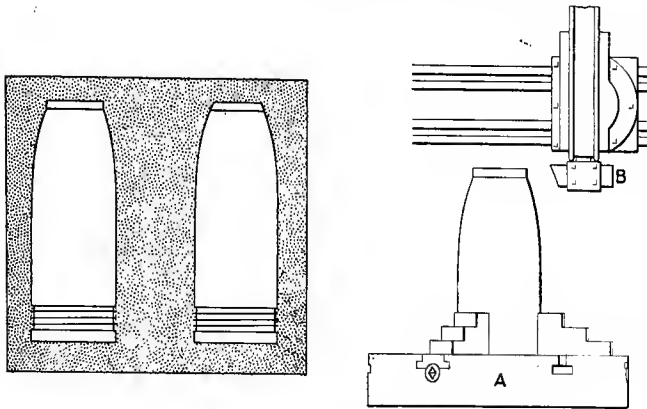


FIG. 67. DETAILS OF SOCKET-THREAD GAGE, SOCKET-THREAD TAP AND NUT AND WEDGE-TYPE DRIVING TOOL FOR THE SOCKETS

screwing them in. One man can screw in about 30 sockets per hour. Sockets which are not screwed down tight when the friction driver slips are screwed to place by hand with a wrench. Less than one per cent. require this treatment.

As the sockets are screwed tight into the shell nose there is a tendency to close some of them slightly. Those which are closed are cleaned out with the tap, shown together with the plug thread gage in Fig. 67.



OPERATION 20—TURNING THE SOCKET

Machines Used—Vertical boring mills.
Special Fixtures and Tools—Universal chuck A set central on table. Formed tool B.
Gages—Radius gage shown in Fig. 46.
Production—One man and one machine 30 per hr.

The shells now go to a small vertical boring mill equipped with a universal chuck for holding them and with a formed tool (the shape of the nose of the shell) mounted in the tool post. The tool is fed sidewise to the cut. One man can finish about 30 per hour.

■

German Cast-Iron Shells

The two views shown emphasize two steps that are being taken in Germany to keep up with the demand for field-artillery ammunition. One of these is the employment of women as machine-tool operators, and the second is the use of cast iron for shell cases.

The first statement needs no proof, the illustrations making it clear that most of the operations, including the inspection of the tapped hole in the nose, are performed by women. However, there is nothing particularly striking in this, since it has been known for some time that other belligerent countries are using women to fill the gaps in their depleted industrial forces.

The striking and original fact that is demonstrated by these views is the *employment of cast iron* as a material for projectiles. Anyone who examines the original

photographs can have no doubt left in his mind of this fact. The characteristic cast-iron chips, the absence of a cutting lubricant, the familiar oil spots that appear on some of the finished pieces, the lack of longitudinal die marks which are always present on forged shells, the gray sheen of the turned surface and the absence of feed marks are all apparent in the original of the first illustration. That the castings even contain a high percentage of steel is doubtful, judging by the nature of the chips. They appear to be from a medium hard gray iron which, as indicated, may be turned on a third belt speed.

The censorship ban has been so strongly enforced on munition making in Germany that it is interesting to note the general process of making these shells. The first operation appears to be done on the outside of the shell, which is held and driven on a split expanding arbor operated by a handwheel through the headstock. The tailstock center is used to steady the piece for the cut, which, as will be noted, is a light one, apparently not over $\frac{1}{8}$ in. in depth.

Nose bottling is avoided altogether in these projectiles, which may possibly be taken as further evidence that they are being made of cast iron. A very slight curve is given to the nose of the case, possibly at the same time that the drive-band recess is formed, although these two operations are not shown in the views.

It is interesting to note in Fig. 2, the simplicity of this drive-band recess, which consists of parallel angular grooves interrupted by a number of gashes cut with a chisel. A comparison of the time necessary to machine a drive-band recess of this form with that of the waved British recess is food for thought.

There is some evidence to indicate that these German shells are not machined on the inside with the exception of the hole that is tapped in the nose. The elimination of these inside boring operations, which take the most time of any on the forged shells, the absence of the bottling operation and of the necessity of heat-treating, and the simplicity of the drive-band recessing operation must make it possible to produce these shells in a remarkably short time. The process appears to have been carefully worked out, even to minor details. For example, in painting the outside of the case the girls use a brush the width of which is equal to the length of the shell. The main idea seems to be supply.



FIG. 1. TURNING CAST-IRON SHELLS



FIG. 2. SIMPLE WAVE BAND RECESS

Manufacturing British 4.5 High-Explosive Shells--VII*

BY E. A. SUVERKROP

SYNOPSIS—The shells now receive the finishing touches. The copper bands are pressed on, the shells varnished inside and baked, the copper bands turned, the shells subjected to the final inspection and painted, the plugs luted in, and finally, under the supervision of the inspector from the shell committee, are packed two in each case.

The next operation, banding, is done in a self-contained banding plant located in that part of the works where the rest of the finishing operations, the final inspection, varnishing, painting, packing and shipping are done. In Fig. 68 at *A* is shown the triple cylinder hydraulic pump which supplies the accumulator *B*. The accumulator delivers the water to the banding press at 1500 lb. per sq.in. The pump is belt-driven from an electric motor. The water supply is drawn from the tank *C*, which is served by the city water supply when "make-up" water is required. As the discharge from the banding press empties into the tank *C*, the water is therefore used over and over again. The wire rope *D* leads over pulleys and on the other end carries a weight supported above the center of the accumulator. When the accumulator is forced up it

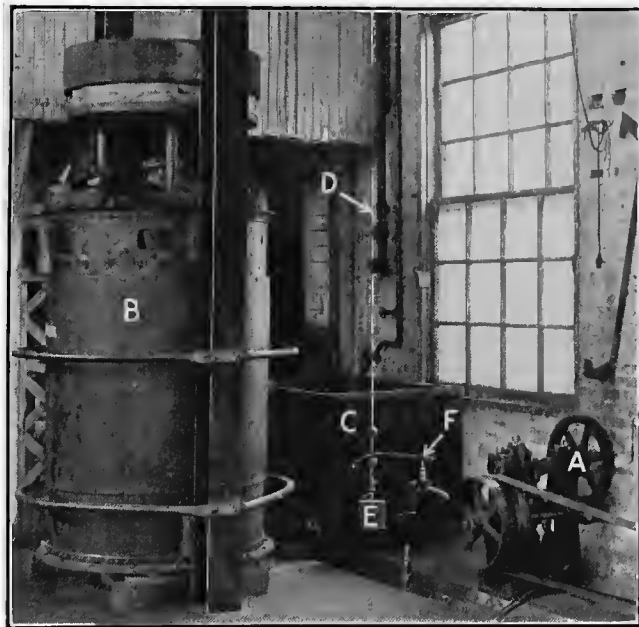


FIG. 68. HYDRAULIC PLANT FOR BANDING

lifts the upper weight, which permits the lower weight *E* to drop and shut off the water suction cock *F*. When the accumulator descends, the upper weight, being greater than the lower weight, opens the suction cock *F*.

PLACING AND COMPRESSING THE COPPER BANDS

The copper bands shown in Fig. 70 are large enough to just slip over the base of the shell. They are sheared from drawn-copper tube or parted from copper cups thick

in the wall. They are narrow enough to just enter the driving band groove. The operation of banding is similar to the method employed for shrapnel. This was so thoroughly covered by Mr. Van Deventer on page 538, Vol. 42, that it need not be repeated here. The press designed and used in the Allis-Chalmers works is entirely different from that shown in the article referred to. As there are many banding presses of this type in use for both shrapnel and high-explosive shells, a description will not be out of place.

The ring-like vertical flange *A*, Figs. 69 and 70, is part of a single steel casting which constitutes the main body of the machines. It carries six pistons *B*, spaced 60 deg. apart, around its inner face. These pistons have

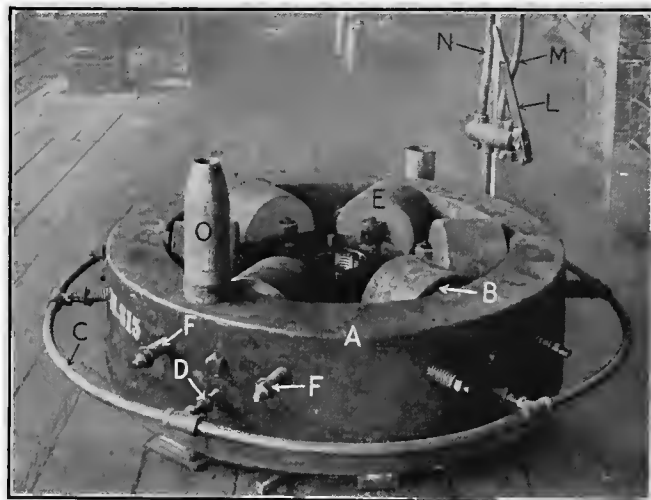


FIG. 69. HYDRAULIC BANDING PRESS

no movement. The forward end of each piston is provided with a hydraulic cup leather. A $\frac{3}{4}$ -in. hydraulic pipe *C* surrounds the steel ring *A*. Branches *D* lead from it through each piston, as shown in Fig. 70.

Mounted on the stationary pistons *B* are six movable cylinders *E*. Their forward or closing movement is caused by the water (under 1,500 lb. per sq.in. pressure) entering through the pistons *B*. Their return, when the pressure is shut off, is assured by the heavy helical springs *F*, of which there are two for each cylinder.

The forward end of each cylinder has a lug *G*. A tap bolt *H* passes through a clearance hole in *G* and is screwed into the rectangular banding punch *I*. The duty of the tap bolt *H* is to withdraw the punch *I* after the band is closed. The pressure of banding is taken by the head of the cylinder and not by the tap bolt, as the latter would be too weak for the purpose. The punches *I* slide in rectangular slots in the central hub *J* and are kept from lifting by a plate *K* secured by cap screws to the hub *J*.

The inner ends of the punches are hardened, and shallow rectangular grooves are cut in them to hold the copper bands.

The banding press is placed on the floor and is not nearly as inconvenient to operate as might be imagined. The operating valve is controlled by the lever *L*. At *M*

*Copyright, 1915, Hill Publishing Co.

Two men are employed on this job. Their output is about 45 shells per hour. The bases of the shells are stamped as shown in Fig. 71. The work is at present done with hand stamps, but later on will be done in a drop press, which with the die is shown in Fig. 71.

VARNISHING THE SHELLS INSIDE

Fig. 72 shows the varnishing table. The shells are first handled by the operator at *A*. After all dust is blown out with an air blast the shell is passed to the varnisher at *B*. The brush is provided with bristles at the end and along one side for about 4 in. from the end. A thin sheet-metal bushing is inserted in the nose of the shell to protect the threads in the socket from the varnish.

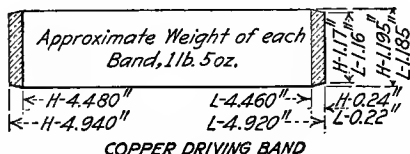


FIG. 70. 225-TON PRESS FOR PRESSING COPPER BANDS ON SHELLS

and prevent them from being filled up. The operator, having first inserted the sheet-metal bushing *D* in the nose of the shell, dips the brush in the varnish pot *C* and inserts it in the shell. The shell is then rolled backward and forward on the table, the brush in the meantime being reciprocated so that the varnish covers the whole inner surface of the shell. When complete, the shell is stood on its base. The excess varnish collects in the base and is removed with a brush before the shell goes to the oven. The varnish must be made from a high grade of African copal gum. The only metallic impurities permitted are: Not more than 0.5 per cent. of manganese; lead calculated as metallic lead (Pb) not to exceed 0.05 per cent.; copper not to exceed 0.1 per cent. Preparatory to passing the shell to the man at *A*, the boy at *E* cleans out the grub screw hole in the socket, using a tap for the purpose.

The shells are now loaded on the iron trays shown in detail in Fig. 54. These are then placed on trucks and run into the baking oven shown in Fig. 73. There are two of these ovens. Three of their sides are lined with live-steam pipes. To bring the ovens to the desired tem-

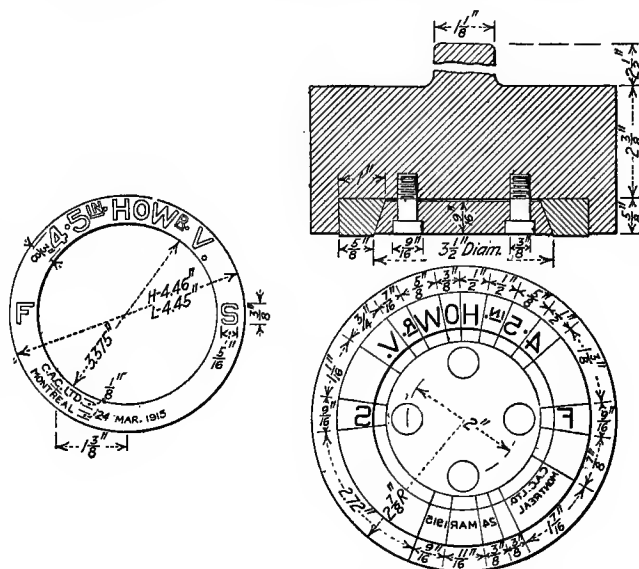


FIG. 71. STEEL DIE FOR STAMPING BOTTOM OF 4.5-IN.
HOWITZER SHELLS

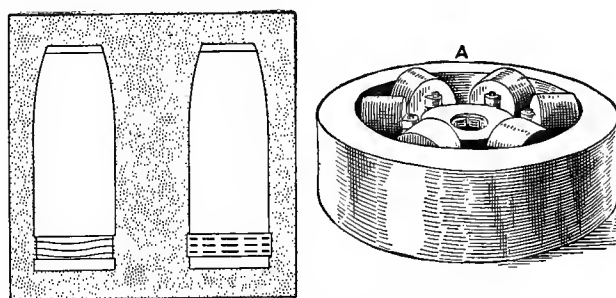
perature electric heaters were necessary. With the arrangement shown the specified 300 deg. F. is readily attained and is maintained for the required 8 hr.

TURNING THE COPPER DRIVING BAND

The copper driving bands are turned on a special lathe which has been evolved from one formerly used for winding electrical apparatus. Three tools are employed as shown in Fig. 74. Details of the lathe are given in Fig. 75.

The photograph from which Fig. 74 is reproduced was taken before the band-turning attachment shown in Fig. 75 had been completed. Discrepancies will therefore be noted when viewing Figs. 74 and 75.

The shell *A* is held in a special universal chuck with extra-long jaws. The rear end is supported by a cup center *B* mounted on the tail spindle, shown in detail



OPERATION 21: BANDING

Machine Used—Hydraulic banding press A.
Special Fixtures and Tools—None.
Gages—None.
Production—From one machine and two men, 45 shells per hr.
References—See Figs. 68, 69 and 70.

in Fig. 75. Beneath the center of the lathe is the first rough-turning tool *C*. This tool is run lengthwise of the lathe. The rough form-turning tool is mounted in front at *D*. By referring to Fig. 75 it will be noted that the crossfeed screw *E* is provided with miter gears *F* and *G*,

which transmit motion to the screw *H*, which actuates the rough-turning tool *C*. The tool block *I* is so located with relation to the tool block carrying the rough-turning tool *C*, and both of them with relation to the rough copper driving band on the shell, that the tool *C* traverses across the copper band and rough-turns

milling cutters and the forming tools with which the milling cutters were made.

In Fig. 77 are illustrated the gages used during and after band turning. Their application is apparent.

In Fig. 78 are shown the government inspectors at work in the final inspection department. When a proof



FIG. 72. VARNISHING TABLE EQUIPPED WITH AIR-BLAST FOR CLEANING

it before the rough forming tool *D* begins to cut. At the back of the lathe is the finish-forming tool *J*, which is carried in a vertical slide and is actuated by the hand lever *K*.

It will be noted that the design of fixture shown in Fig. 75 provides a roller steadyrest to support the shell

shell has been selected, passed through the various manufacturing operations to rapid completion and submitted for proof, the final examination of the other shells in the lot is proceeded with in the usual way without waiting for proof results from such shell. The finished shells weigh 27 lb. 10 oz., with an allowance of plus 2 or minus 4 oz. The inspection operations for the final inspection are enumerated in Table 2. Shells which are found cor-

TABLE 2. INSTRUCTIONS FOR FINAL INSPECTION OF 4.5 HIGH-EXPLOSIVE SHELLS

No. of Operation	Operation	Per Cent. to Be Done
*13	Testing base plate for looseness.....	100
14	Screw gage, fuse hole, high and low.....	100
15	Examination of threads in fuse hole.....	100
16	Depth of recess fuse bush.....	...
17	Diameter and angle of recess.....	...
18	Internal examination for flaws and varnish.....	100
19	Weight.....	100
20	Width of driving band and distance from base.....	100
21	Form of driving band.....	100
22	Distance of fixing screw hole.....	100
23	Serrations on driving band.....	100
24	Hammer test, driving band.....	100
25	Center punch test driving band.....	As required
26	Form and radius of head.....	100
27	Concentricity and cylinder gage.....	100—20% for concentricity
28	Length overall.....	20—shells for fixed ammunition, 100
29	Plug gage, plain part of socket.....	100
30	Examination of markings on body and base.....	100
31	Examination for cast and code number.....	100
32	Diameter of driving band, high and low.....	100
33	Diameter of rear part of driving band.....	100
34	Stamping work marks, etc.....	...
35	Greasing and fixing plugs and setscrews.....	100
36	Ring gage, diameter over paint.....	100

* This test will be made by the inspector in the open shop as soon as the base plate has been inserted and machined off.



FIG. 73. VARNISH-BAKING OVEN

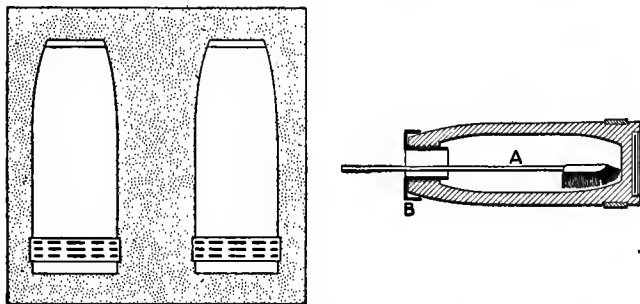
close to the copper band. However, the cup center is quite satisfactory, and one man can turn about 20 driving bands per hour.

In Fig. 76 are shown the tools for turning the copper bands. They are made of high-speed steel and milled in 12-in. lengths. In this illustration are also shown the

rect are stamped with the inspectors' work marks in the following manner, as indicated also in Fig. 61:

A work mark is placed immediately below the fuse-hole bush or nose of the shell to indicate the correctness of the fuse-hole examination and gaging and internal examination. The serviceable sign is stamped above it to signify

The serviceable sign, which is the British broad arrow within a C, will not, however, be stamped until results of the proof and varnish tests are received. While awaiting



OPERATION 22: VARNISH INSIDE

Machine Used—None.
Special Fixtures and Tools—Varnish brush A; sheet-metal bushing B; varnish pot.
Gages—None
Production—From one man, about 30 shells per hr.
Reference—See Fig. 72.

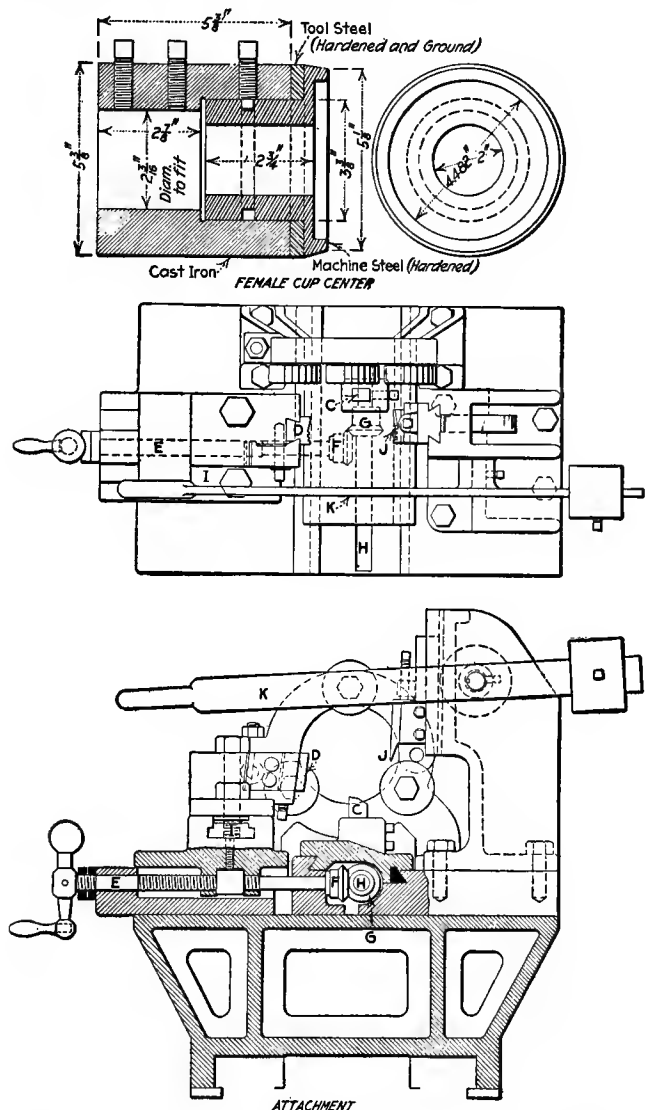


FIG. 75. ATTACHMENT FOR TURNING COPPER BANDS

the receipt of these the shells may be painted and laid out for drying.

Reports on the preliminary and final inspection are kept on forms supplied by the government.

From each consignment of varnish which the contractor proposes to use one-quarter pint is taken by the inspector,

put in bottles supplied for the purpose and forwarded by express to the government analyst.

Varnish is also scraped from proof and defective shells. A sample, at least 1/4 oz. in weight, must be obtained, and this governs five lots of shells. The least delay is occasioned if the samples are obtained from proof shells. The

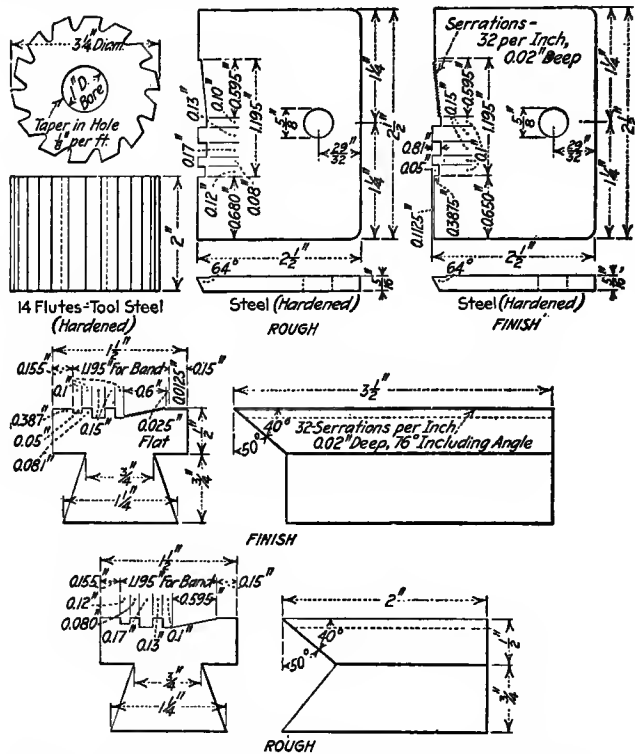
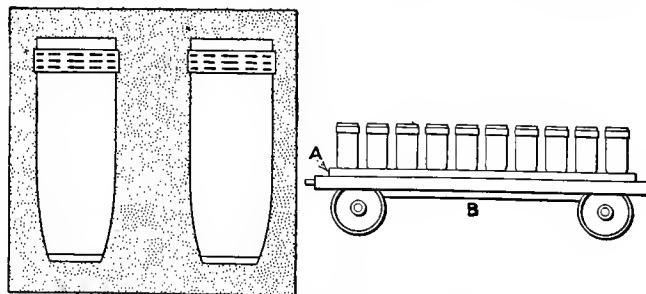


FIG. 76. MILLING CUTTERS AND TOOLS FOR COPPER DRIVING BAND

contractor is not informed from which proof shell scrapings are to be taken. Inspectors insist on proof shells being submitted with as smooth and dry surfaces as is required for the general run of shells. Any failure on the contractor's part to comply with this results in withdrawal of the privilege of expediting the completion of proof shells. The scrapings are also forwarded by express, in the bottles supplied, to the government analyst.

All samples, liquid varnish and scrapings must be clearly labeled. The label for the liquid sample shows the



OPERATION 23: BAKE VARNISH

Machine Used—None.
Special Fixtures and Tools—Iron trays A, each for 50 shells; iron trucks B; steam- and electric-heated ovens; thermometer reading to 300 deg.; clock.
Gage—None.
Production—From two ovens, about 400 shells in 8 hr.
References—See Figs. 54 and 73.

firm which supplied the varnish, the firm which received it, the amount of the consignment and the date received. The bottles containing the scrapings are labeled to show the name of the firm, the lot or lots from which the sample



FIG. 78. FINAL GOVERNMENT INSPECTION FOR WEIGHT AND DIMENSIONS OF FINISHED SHELLS

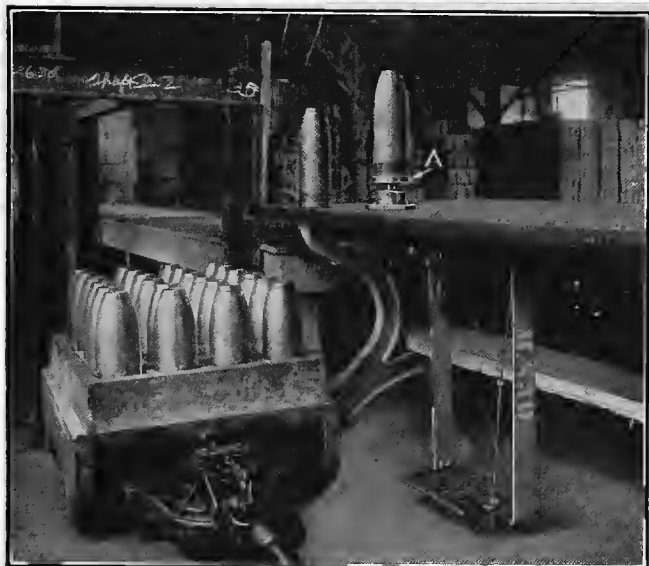


FIG. 79. PAINTING STAND EQUIPPED WITH TURNTABLE

is actually taken and the lots which will be governed by the sample.

The results of the analysis are reported to the inspection office at Quebec, which notifies the manufacturers when the lots successfully pass the proof and varnish tests.

When scraping the varnish from the shell the following points are to be strictly attended to:

1. The nose of the shell down to 2 in. from the fuse hole outside, and the threads, are to be wiped clean with a clean piece of rag or waste.

2. The scraper to be in a polished and bright condition, and kept for this purpose only.

3. The examiner is to have clean hands.

4. The paper on which the scrapings of varnish are collected is to be clean and is not to have been previously handled.

5. To insure that no brass shall be scraped off the fuse socket the fuse hole must be protected by a leather or cardboard liner, or else the sockets must be removed while the scraping operation is being performed on the shells.

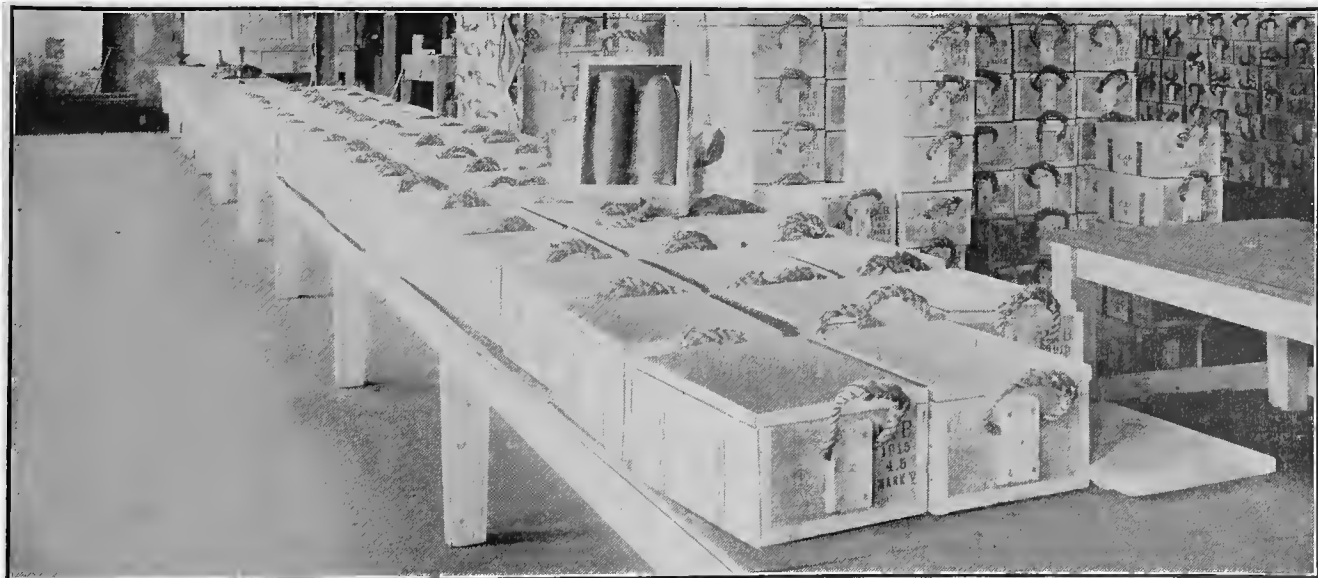


FIG. 80. VIEW IN THE SHIPPING DEPARTMENT, SHOWING TYPE OF PACKING CASES USED

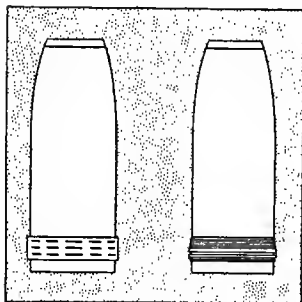
The shells are next washed with gasoline to prepare them for painting. The whole of the body is covered first with a priming coat made up of the following ingredients: Dry zinc oxide free from lead, 9¾ lb.; boiled linseed oil free from lead, 1¼ pints; terebene free from lead, 1¼ pints; spirits of turpentine 1½ pints. It is of the utmost importance that the ingredients employed in paints for lyddite shells shall be absolutely free from lead for the reason already given. It is therefore required that samples of ingredients be submitted to the Chief Inspector of Arms and Ammunition, Quebec, for chemical analysis to guard against the presence of lead in the paint.

After the first coat is thoroughly dry in the air the second coat is applied. It consists of dry Oxford yellow

F., and is to be free from solid mineral matter. The castor oil must be genuine. The whiting is to be of the quality known as "Town Whiting" and is to be free from moisture.

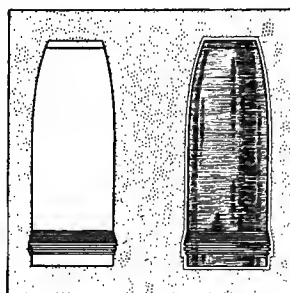
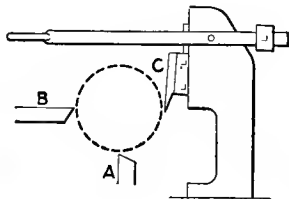
LUTING AND PACKING

The luting, when finished, must be thoroughly mixed, plastic and free from lumps. If on examination of a sample of 10 per cent. of the invoice it is found that the sample does not comply with the specification, all the material invoices will be rejected without further examination. The luting may be inspected during the manufacture by, and after delivery will be subject to test and



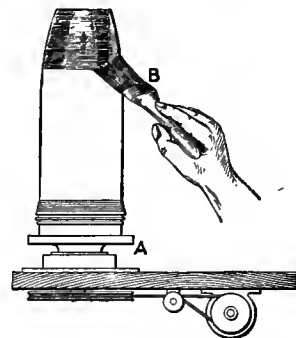
OPERATION 24: TURN DRIVING BAND

Machine Used—Special lathe.
Special Fixtures and Tools—Special chuck cup tail-center; rough-turning tool A; rough-form tool B; finish-form tool C.
Gages—High and low calliper gages and contour gages.
Production—One machine and operator, 20 per hr.
References—See Figs. 74, 75, 76 and 77.



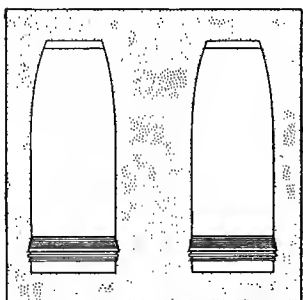
OPERATION 26: PAINTING

Machine Used—Motor-driven turntable A.
Special Fixtures and Tools—Paint brush B.
Gage—None.
Production—One man, 40 per hr.
Reference—See Fig. 79.



to the final approval of, the Chief Inspector, Royal Arsenal, Woolwich, or an officer deputed by him.

In Fig. 80 is shown the shipping room. In the center is a box packed and ready for inspection before the lid is screwed down. Inspection at this stage is in charge of a man appointed by the Canadian Shell Committee. He



OPERATION 25: FINAL GOVERNMENT INSPECTION

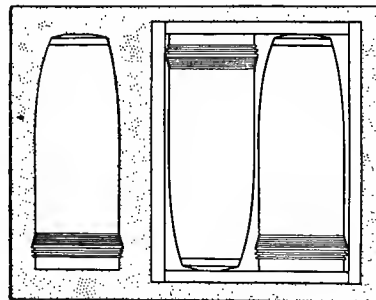
Machine Used—None.
Special Fixtures and Tools—Weighing scales; inspectors' stamps and hammer.
Gages—Complete set to cover all dimensions.
Production—Five men at this writing handle the entire inspection for about 1,500 shells per week.
References—See Figs. 61 and 78.

stone ochre, 8½ lb.; boiled linseed oil free from lead, 1¼ pints; terebene free from lead, 2½ pints; spirits of turpentine, 1½ pints.

The paint is applied to the surface of the shell as it rotates at about 200 r.p.m. on the electrically driven turntable A, Fig. 79. The table is controlled by a foot-operated switch. One man can paint about 40 shells per hour. When the second coat is dry the brass plugs are luted and screwed into the sockets, thus completing the job.

The luting consists of 80 parts of whiting and 21 parts of oil, both by weight, kept fluid by heating. The materials are to be of the best quality. The oil is 20 parts vaseline and 1 part castor oil well mixed before it is added to the whiting.

The vaseline is to be a genuine mineral residue without any foreign mixture. It should have a flash point not below 400 deg. F. and a melting point not below 86 deg.



OPERATION 27: PACKING

Machine Used—None.
Special Fixtures and Tools—Screwdriver.
Gage—None.
Production—One man can pack and close about 15 cases per hr.
Reference—See Fig. 80.

sees that each box contains two shells laid "heads and tails" and "hefts" the weight of the shells. It is a fact that the inspectors in the final inspection can before weighing almost invariably guess whether a shell will pass the weight requirements. When one takes into consideration that the total allowable variation is only 6 oz. in approximately 28 lb. this is remarkable.

It must be remembered that in an industry as new as shell manufacture is to most shops now engaged in it, the practice is likely to change from time to time. The practice covered in this series of articles has met the requirements of both accuracy and production.

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